

AUTOMOBILE ENGINEER

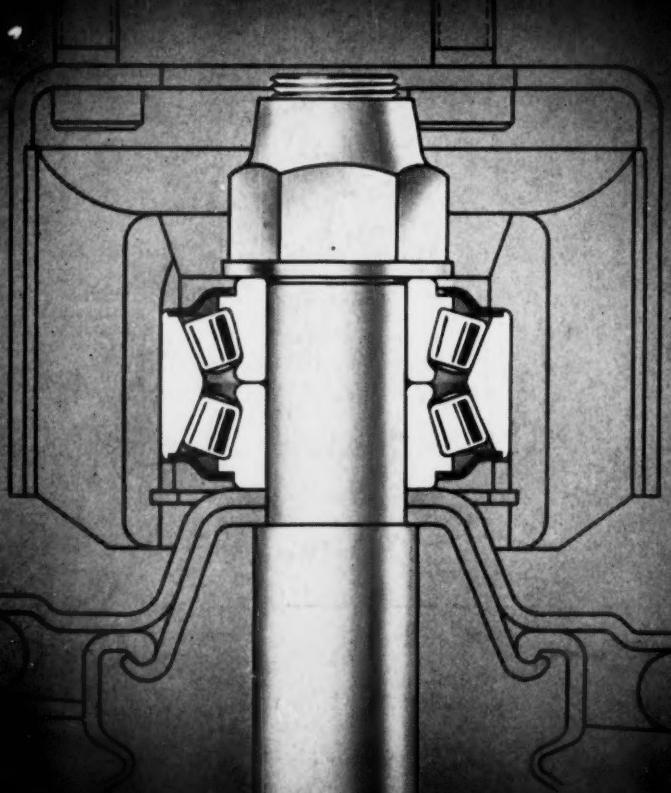
DESIGN · PRODUCTION · MATERIALS

Vol. 43 No. 574

DECEMBER 1953

PRICE: 3s. 6d.

ON THE CONSUL AND ZEPHYR SIX



An interesting front suspension
with

TIMKEN

REGISTERED TRADE MARK: TIMKEN

TAPERED-ROLLER BEARINGS

MADE IN ENGLAND

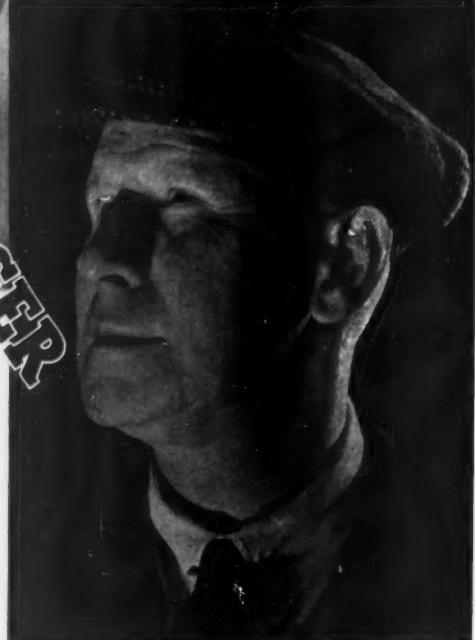
BRITISH TIMKEN LTD., DUSTON, NORTHAMPTON; AND BIRMINGHAM

CYCLONE HACKSAW BLADES

THEY KEEP ON CUTTING LONGER

The secret of this lies in the rigid control exercised from the raw material to the finished job—a factor ensuring the production of blades of maximum efficiency.

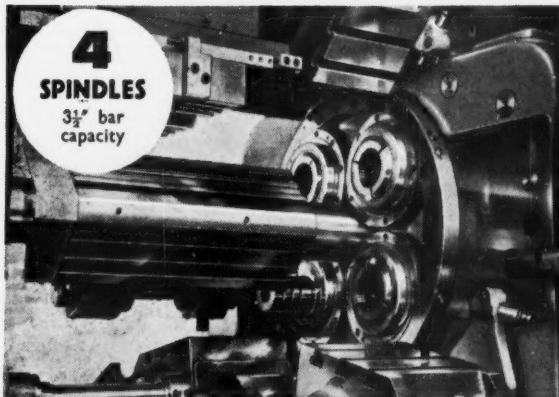
Whatever your needs, we can supply hacksaw blades which will "keep on cutting longer."



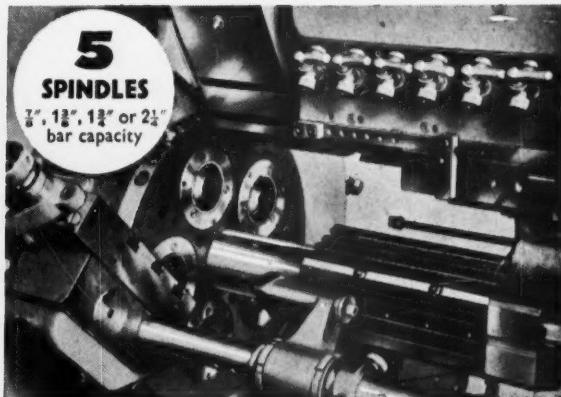
ENGLISH STEEL CORPORATION LTD.
Holme Lane Works, Sheffield



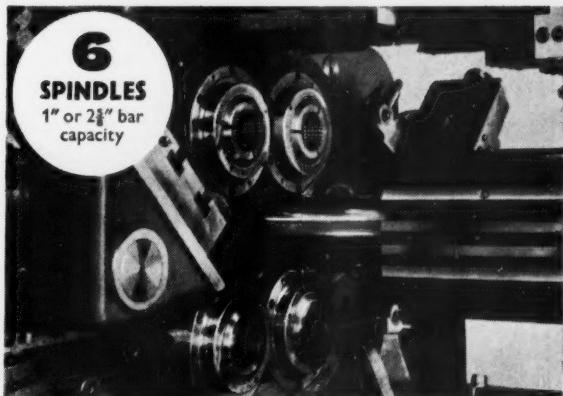
FOUR, FIVE, SIX AND EIGHT SPINDLE AUTOMATICS provide production engineers with new opportunities to increase output and lower costs



4 SPINDLES
3½" bar capacity



5 SPINDLES
3", 3½", 4", 4½" or 5" bar capacity

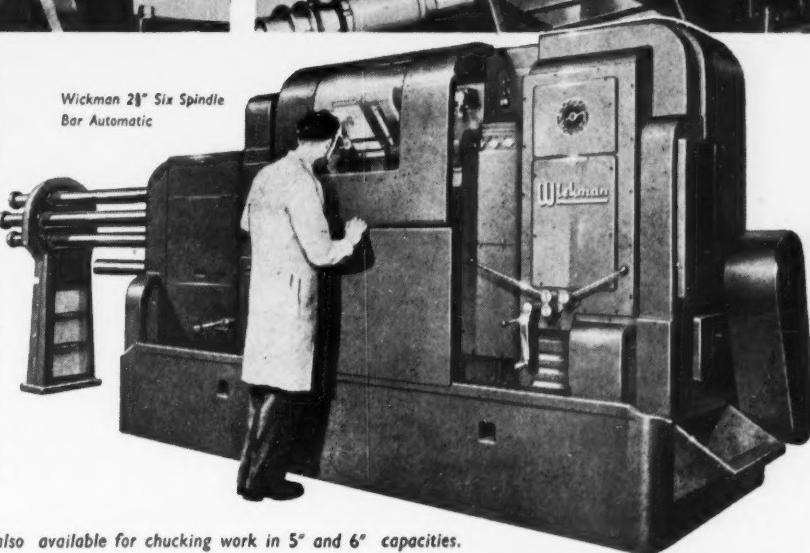


6 SPINDLES
1" or 2½" bar capacity



8 SPINDLES
12" bar capacity

Fast producing Wickman Multi-spindle Automatics can now be applied to a wider range of jobs than ever before. The tooling opportunities can be easily visualised from the illustrations above. The Wickman patent auto-setting mechanism is incorporated in all machines of the range and alterations to tool feed strokes and bar feed are accomplished without cam changing. The full fast approach stroke is unaltered by this mechanism, setting up is simplified and change-over time reduced—that's why these automatics can be considered for short run jobs as well as long runs on one component.



Wickman 5-spindle automatics are also available for chucking work in 5" and 6" capacities.

WICKMAN of COVENTRY

LONDON • BRISTOL • BIRMINGHAM • MANCHESTER
LEEDS • GLASGOW • NEWCASTLE • BELFAST



200 WM



Rover Car Factory, Solihull. High intensity lighting in a body spray tunnel by fluorescent lamps in a glazed enclosure.

Tailored for the job

The lighting of many processes is vital to the smooth and rapid flow of work and to the quality of the finished product. For example, poor lighting could make a spray tunnel into a bottle-neck — each job taking a little too long, a little portion missed, a return to the spray line — and so the whole production line marks time. Whatever form it takes, good lighting not only helps to provide a satisfactory working environment but is an active production tool.

Fluorescent lighting is as good as daylight — only more consistent. It is efficient; it is economical; and it is flexible. You can 'tailor' it, easily and exactly, to the special requirements of production at all stages.

Electricity for PRODUCTIVITY

HOW TO GET MORE INFORMATION

Your Electricity Board will be glad to advise you on how to use electricity to greater advantage — to save time, money, and materials. The new Electricity and Productivity series of books includes one on lighting — "Lighting in Industry". Copies can be obtained, price 9/- post free, from E.D.A., 2 Savoy Hill, London, W.C.2, or from your Area Electricity Board.

Issued by the British Electrical Development Association



TOUCHÉ !

"On the wrong foot again, old boy.

When will you learn . . . ?"

"Don't sound so glum —

you've taught me one thing —

and I'm your humble servant."

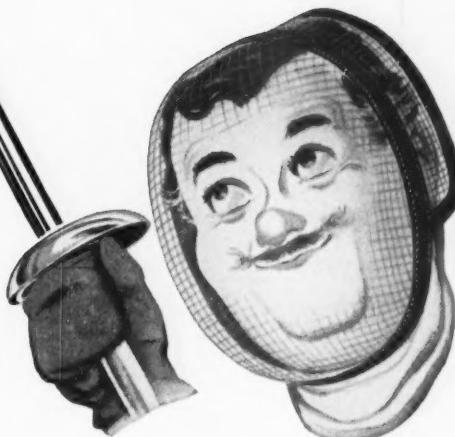
"Ah! back to M. & C. Service —

my 'coup de grace'."

"When I've been at it as long as you —

I might make a better showing."

"Never a moment's worry! On your Guard!"



BRITAIN'S FOREMOST DISTRIBUTORS

MONKS & CRANE LTD

THE TWIST DRILL SPECIALISTS

HEAD OFFICE:

STANHOPE STREET • BIRMINGHAM 12 • Tel: CALthorpe 1381 (5 lines)



MANCHESTER OFFICE:

MANCHESTER OLD ROAD
RHODES, MANCHESTER

Tel: Middleton 3654 (3 lines)

LONDON OFFICE:

295 EUSTON ROAD
LONDON, N.W.1

Tel: EUSton 5311 (3 lines)

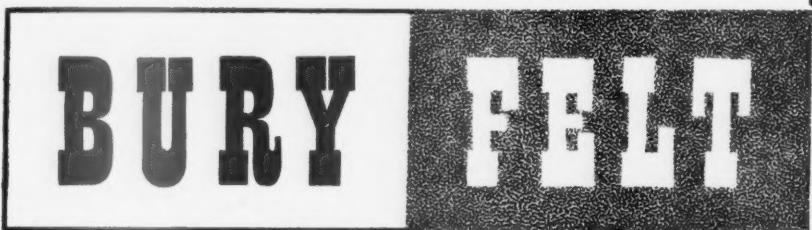
GLASGOW OFFICE:

79, CROWN STREET
GLASGOW, C.5

Tel: South 2907 (3 lines)

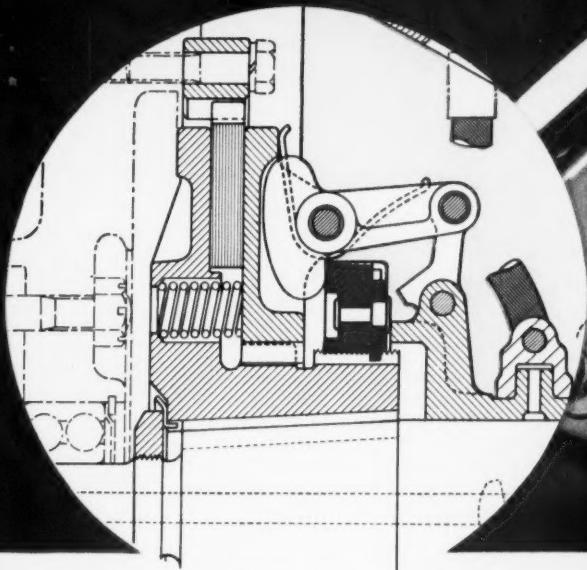
Precisely correct for your purpose . . .

To make sure that Bury Felts will stand up to hard work and particular stress, samples of all these famous felts are rigorously and scientifically tested before leaving the factory. Each selected sample is stretched to test its behaviour under strain, and its conformity with the predetermined breaking point. This means that whatever use you make of Bury industrial Felts you can be sure they will give you the most reliable service. They can be die-cut, chiselled, punched, machined, and even ground. Put Bury Felts to work in filters, seals, washers, gaskets, buffing rollers, shock-absorbing mountings and cushionings—or in any one of the hundreds of different ways these versatile materials can be used.



Send your enquiries to:

BURY FELT MANUFACTURING COMPANY LIMITED
HUDCAR MILLS, BURY, LANCS. Phone: BURY 2262 (6 lines)
or to the London Office: 3 Snow Hill, E.C.1 Telephone CENTRAL 4448



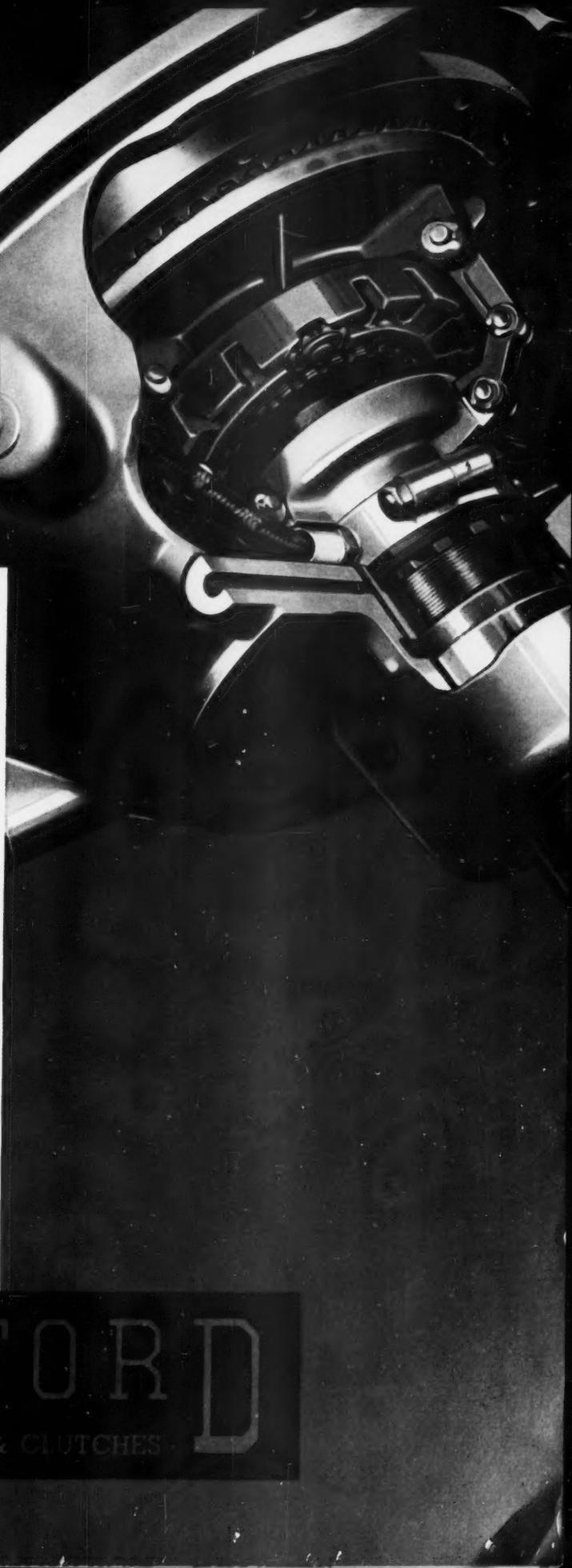
Simple adjustment

The Rockford clutch, with its centrifugally-balanced and effective toggle-action, gives a smooth engagement without imposing any running thrust either when engaged or disengaged.

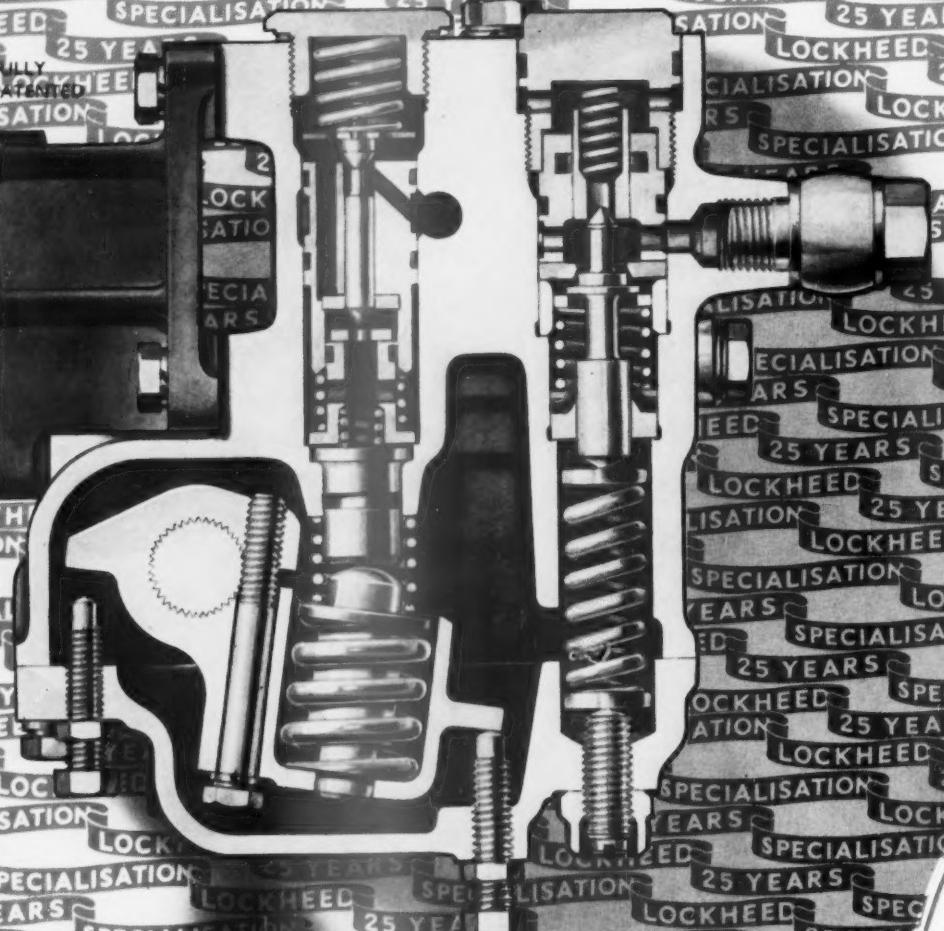
An exclusive device gives, without special tools, an infinitely close adjustment. Fine adjustments can be made, and automatically maintained, without releasing or engaging separate locking devices, which formerly limited adjustments to spacing controlled by notches or holes. The adjustment ring is conveniently accessible, and is painted red for easy identification.

British made, in a range of sizes, by

BORG & BECK COMPANY LTD.
LEAMINGTON SPA, ENGLAND



ROCKFORD
POWER TAKE OFFS & CLUTCHES



LOCKHEED

THE HEART OF THE SERVO

The power valve system

In this type of Lockheed Servo system, used on trolley buses, and elsewhere, where it is desired to have an extremely light brake-pedal pressure, a master cylinder is not employed, the fluid for brake operation being derived direct from the pump or pressure reservoir.

In the unit illustrated, the cut-out valve and power valve are combined.

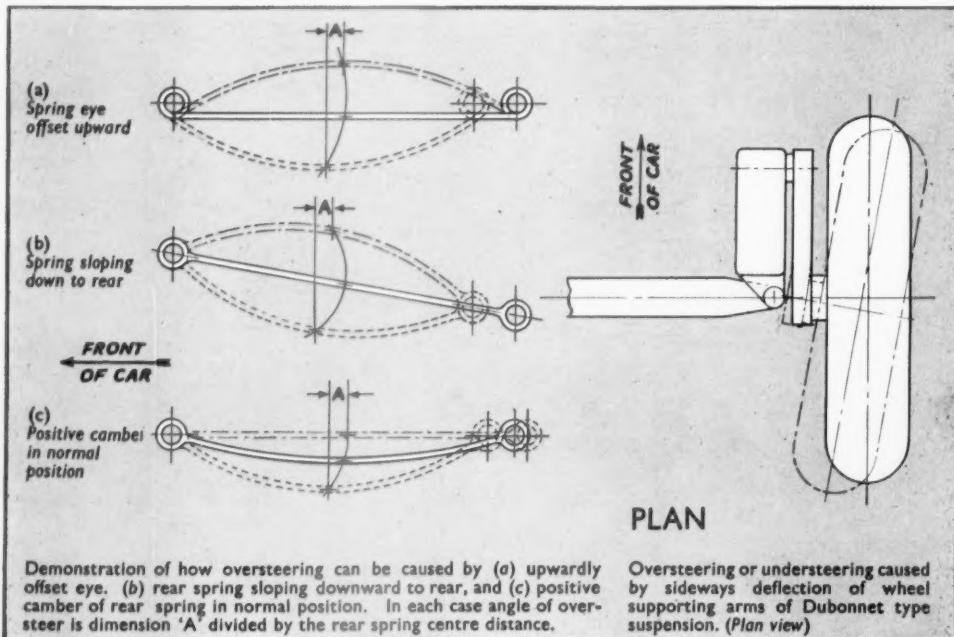
The system balances the brake-line pressure against the pedal pressure, giving normal feeling of control.

When subsidiary services, such as power-assisted steering, door-opening equipment etc., are added, a secondary pressure reservoir is employed, in conjunction with a non-return valve leaving the primary pressure reservoir for brake operation only.

AUTOMOTIVE PRODUCTS COMPANY LIMITED, LEAMINGTON SPA, ENGLAND

SUBTLETIES OF STEERING

Causes of over- and under-steer: 6. Car properties (c) 'Roll steer'



Demonstration of how oversteering can be caused by (a) upwardly offset eye, (b) rear spring sloping downward to rear, and (c) positive camber of rear spring in normal position. In each case angle of oversteer is dimension 'A' divided by the rear spring centre distance.

Oversteering or understeering caused by sideways deflection of wheel supporting arms of Dubonnet type suspension. (Plan view)

WE must not forget, in considering the car properties which affect its behaviour in over- and under-steer, that there are direct influences called 'roll steer' as well as the indirect influences which we have so far been considering and which act through the tyre properties.

'Roll steer' can exist at both front and rear of a car. In its simplest and most obvious form, it is the movement of a beam axle in plan view by some influence which acts as the car rolls on a corner as a result of sideways acceleration and the corresponding forces. The semi-elliptic leaf spring, in locating the axle, behaves like a link whose effective length is about three quarters of its half length. If these links (one on each side of the car) are parallel with the ground in their initial position, then rolling of the car will move each end of the axle forwards or backwards by the same amount and there is no 'roll steer'. This happy condition can only exist at one state of load of the axle concerned. If the springs are fixed at their front ends and if the effective links slope downwards towards the axle; then roll will move the outer end of the axle backwards in relation to the inner (Bastow, "Steering Problems & Layout", Proc. I.A.E. 1937-8) and will in effect increase the drift angle for that pair of wheels by this steering angle of the axle.

'Roll steer' can also occur on a front axle if the geometry of the steering drag link is not perfect (and may in that case differ between right hand and left hand corners), and exists with independent front suspension if the geometry of the steering connections is imperfect in such a way that steering

angle occurs on bump and rebound, and if the amount of 'toe-in' for equal amounts of bump and rebound is not the same.

Undue initial 'toe-in' on the front wheels gives an oversteer tendency, because as the weight is transferred to the outer wheel on a corner it tends to take charge and therefore reduce the effective front drift angle.

There are other possible ways of causing 'roll steer', for instance by elastic deflection of parts when subjected to the sideways loads of cornering, but we need not consider every such possibility in detail. Readers can no doubt work out their own possibilities or actualities.

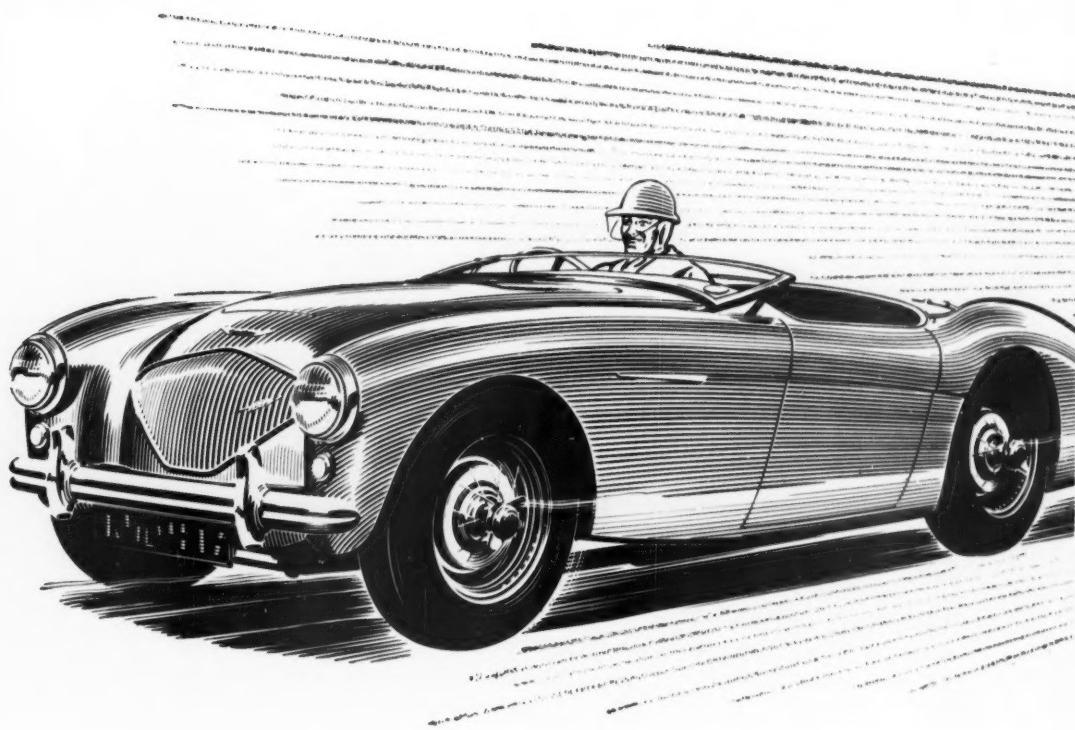
In general, excessive resultant 'roll steer' is to be avoided, because it tends to peculiarities of behaviour in the transient state at the beginning and end of a corner, and because it implies differences in behaviour between the unrolled and rolled car. If under-steer is obtained only by 'roll steer' effects, then it is not present when a car is hit by a gust of wind, and one of the reasons for liking under-steer is the stability it provides in gusty conditions.

Where a rear axle is located by semi-elliptic springs (Hotchkiss drive) it does provide some measure of correction for increasing load at the rear of the car, since reduction of standing height at the rear gives an under-steer tendency, whereas the extra weight on the tyres which causes this reduction in standing height will, as we have seen, increase the over-steer tendency.

Thompson
Self-adjusting

STEERING ROD ASSEMBLY

AUTOMOTIVE PRODUCTS COMPANY LIMITED, LEAMINGTON SPA, ENGLAND



Helping to put the Austin-Healey *first*

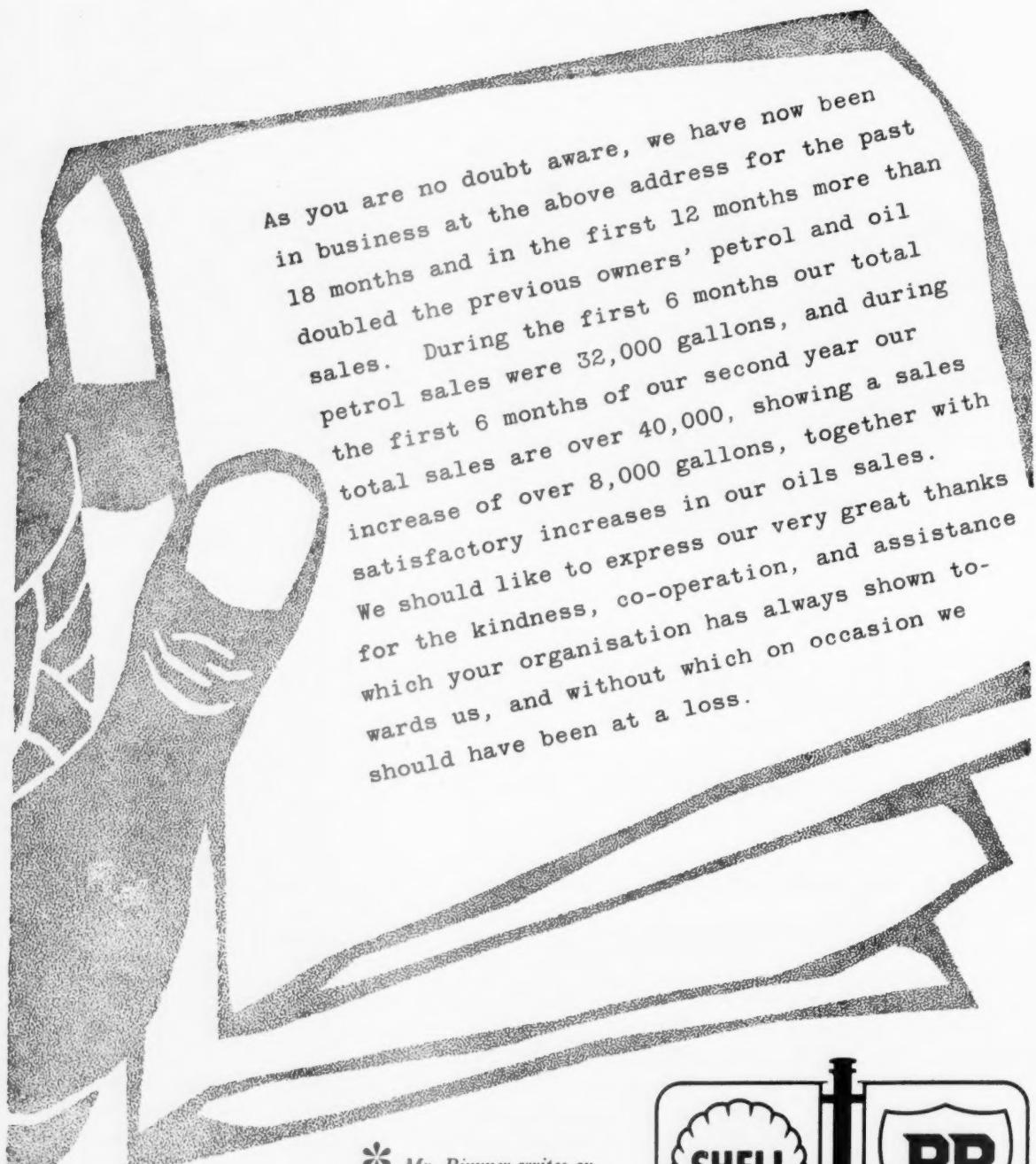
The world record-breaking Austin-Healey 100

car was equipped with bodywork entirely fabricated
in T. I. Aluminium Alloy, specification T. I. 111.



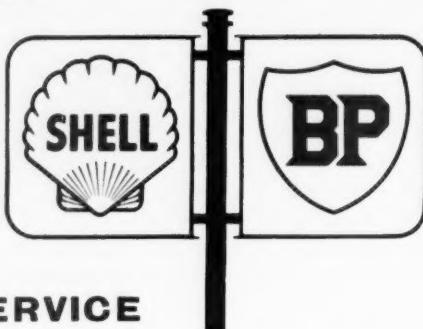
T. I. ALUMINIUM LIMITED, REDFERN ROAD, TYSELEY, BIRMINGHAM 11. Telephone: Acocks Green 3333
Aluminium and Aluminium Alloy Ingots, Billets, Slabs, Sheet, Strip, Plate, Tubes and Extrusions to all Commercial, A.I.D. and Lloyd's specifications

Glad to be of service, Mr. Rimmer*



As you are no doubt aware, we have now been in business at the above address for the past 18 months and in the first 12 months more than doubled the previous owners' petrol and oil sales. During the first 6 months our total petrol sales were 32,000 gallons, and during the first 6 months of our second year our total sales are over 40,000, showing a sales increase of over 8,000 gallons, together with satisfactory increases in our oils sales. We should like to express our very great thanks for the kindness, co-operation, and assistance which your organisation has always shown towards us, and without which on occasion we should have been at a loss.

* Mr. Rimmer writes on behalf of Riddington and Rimmer (Birkdale Garages) Ltd. Southport.



THE SIGN OF FRIENDLY SERVICE

"The castings are characterised by dimensional accuracy, good surface finish, soundness and freedom from hard spots"



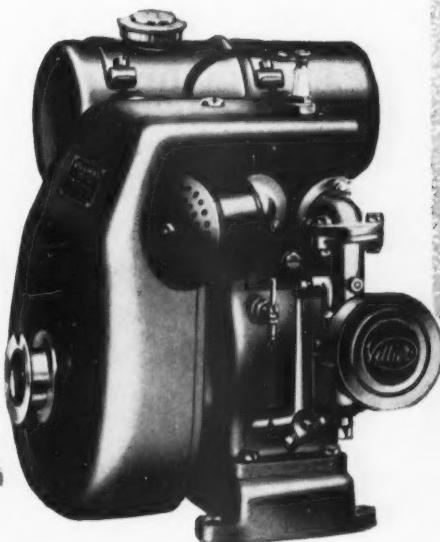
SAY

The Villiers Engineering Company Ltd., purchase several types of Harper Castings, including camshafts in Meehanite. They say: "In regard to all castings supplied our experience shows that the castings are characterised by dimensional accuracy, good surface finish, soundness and freedom from hard spots. The percentage of castings rejected is extremely low, and we have found consistently good machining characteristics.

We choose Harper castings firstly for quality and secondly for reliability of delivery. We have dealt with Harpers for many years, and we consider that they have contributed to a considerable extent to maintaining the high reputation of Villiers engines, which are sold in very large quantities throughout the world".

Harper quality covers iron castings, and also metal pressings, machining, enamelling and other finishes and sub-assembly work.

HARPER CASTINGS

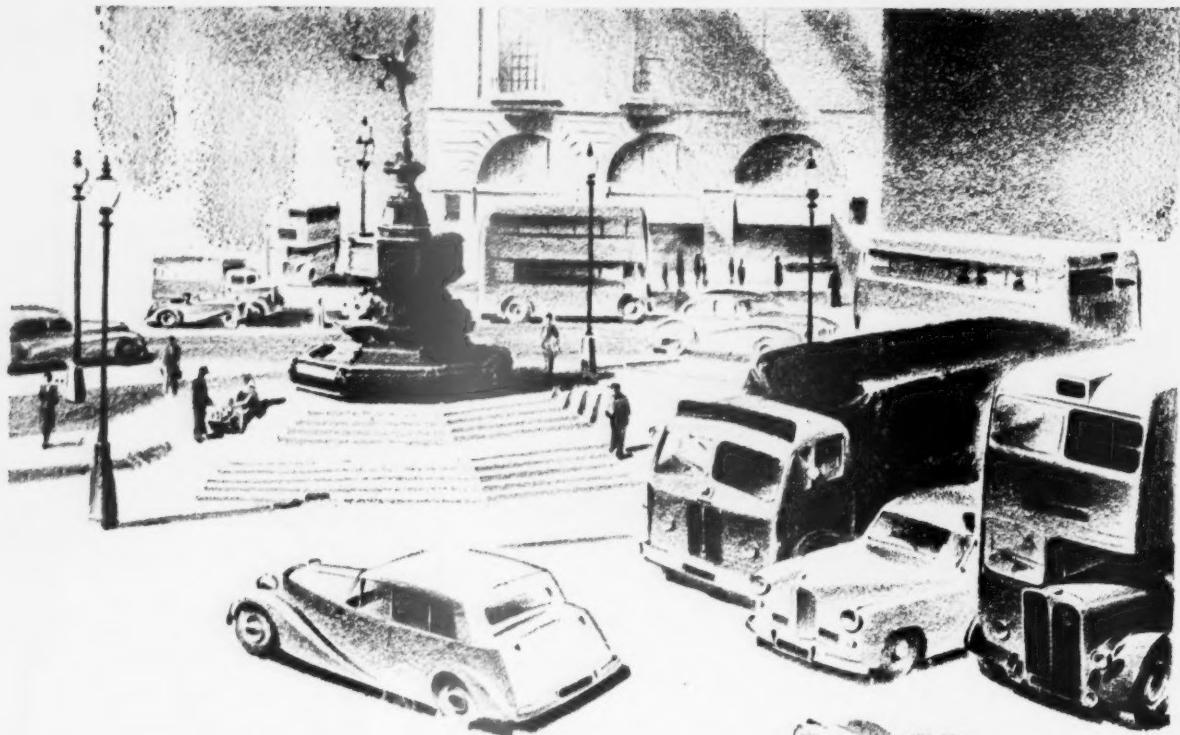


JOHN HARPER & CO. LTD. JOHN HARPER (MEEHANITE) LTD.
ALBION WORKS Phone. WILLENHALL 124 (5 lines) Grams: HARPERS, WILLENHALL **WILLENHALL**

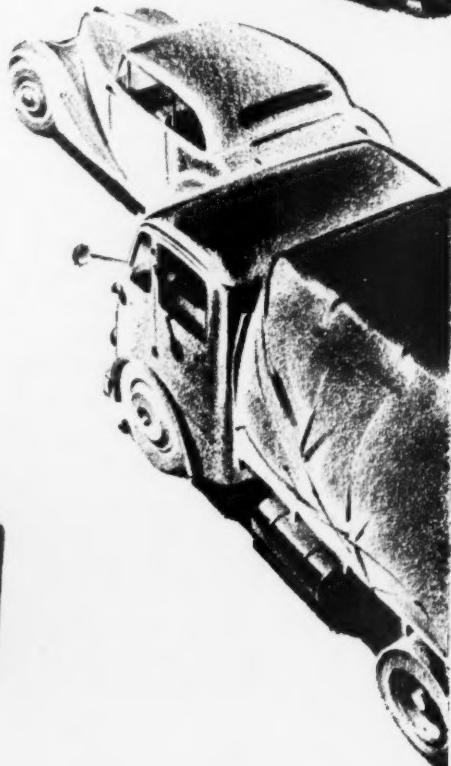


LONDON OFFICE: SEAFORTH PLACE, 57, BUCKINGHAM GATE, LONDON S.W.1 Tel.: TATE GALLERY 0286

H394



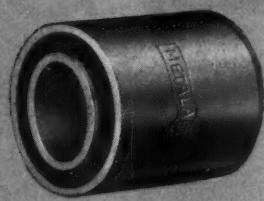
**Standard Equipment
for British Motor Cars
and Commercial Vehicles**



THE RENOLD & COVENTRY CHAIN CO LTD · MANCHESTER

Write for Catalogue Ref. 115/07/29-F

ON THE FORD
Consul & Zephyr



TWO ULTRA-DUTY BUSHES ARE FITTED



ALSO TWO PAIRS OF BONDED-CONE
BUSHES



AND TWO PAIRS OF BONDED-CONE
TUBE BUSHES

I·F·S has many variants but few have departed so boldly from the now-conventional wishbone as the Ford design. This takes the fullest advantage of modern rubber engineering and utilizes Metalastik Ultra - Duty bushes and Bonded-Cone bushes. These, with a sustained behaviour unequalled by any other bushes, are used at all three critical points controlling the front-end geometry, resulting in handling properties that evoke warm praise.

METALASTIK

METALASTIK LTD., LEICESTER

IF IT'S A QUESTION OF

TUBES



We go to any lengths to help you, at Walkers. Tubes of all types and sizes, thicknesses and shapes which can be supplied immediately—the selection's wide; the quality's good.

If you need advice on the most suitable type of tube for a particular job, a 'phone call or a letter will bring prompt assistance, without obligation, from one of our experts.

At Walkers we have the goods—and the "know-how"—to help you.

YOU CAN GET THEM ALL FROM WALKERS

Complete London stocks include:

Steel, Gas, Water and Steam Tube, BSS/1387 ; Seamless Steel Tube, Cold Drawn and Hot Finish ; Electrically Welded and Electric Resistance Welded Steel Tube, Bright and Semi-Bright Finish ; Stainless Steel Tube, Seamless and Welded ; Brass Tube, Seamless and Welded ; Copper Tube for Domestic Water Services BSS 659/1944 ; Copper Tube for Underground Services BSS 1386/1947 ; Copper Tube for all Commercial Services ; Conduit Steel Tube, Welded and Solid Drawn; Aluminium Tube.



M. W. WALKER & STAFF LTD

ENGINEERS MERCHANTS

IBEX HOUSE • MINORIES • LONDON • E.C.3

'Phone : ROYal 8191 (10 lines) 'Grams : Makerlaw, Fen, London

MIDDLE EAST BRANCH — BAHRAIN PERSIAN GULF



**FOR QUICK
DELIVERY
4 BRANCHES
at your
service**

STEEL SHEETS

Cold-reduced : Hot-Rolled
Galvanized or black,
also mild steel plates
up to and including $\frac{1}{2}$ in.
SHEARED TO YOUR SIZES

*May we send you our stock list?
If you would like to have it regularly,
kindly drop a card to our nearest branch*

SPENCER

H. F. SPENCER & CO. LTD., WOLVERHAMPTON

Your Problem?



The use of 'O' rings on reciprocating pistons

In this Climax Rock Drill and Engineering Works Limited's 'Maxam' Control Valve efficient sealing of the Piston is obtained by use of Dowty 'O' Section Ring Seals. Despite constant passage across port faces these seals ensure reliable functioning of this air valve.

A wide range of sizes are available and we shall be pleased to receive details of your specific requirements.

'O' rings by **DOWTY**

DOWTY SEALS LIMITED · ASHCURCH · GLOS.

10% EXTRA OUT OF THE BLUE



"SPEEDICUT" DRILLS

FIRTH BROWN TOOLS LTD.
SPEEDICUT WORKS, CARLISLE STREET EAST,
SHEFFIELD, ENGLAND

Sterling Castings for Motor Cars



STANDARD Vanguard

GEAR BOX AND CLUTCH
HOUSING DIE CAST
IN ALUMINIUM ALLOY



CYLINDER BLOCK IN
"STERLING" CAST IRON

Illustrations by courtesy of The
Standard Motor Company Ltd.



by

STERLING METALS LTD.

Coventry

TELEPHONE: COVENTRY 89031 (6 lines)
TELEGRAMS: STERMET PHONE COVENTRY

OUR ENGINEERS ARE READILY AVAILABLE FOR CONSULTATION ON NEW PRODUCTS

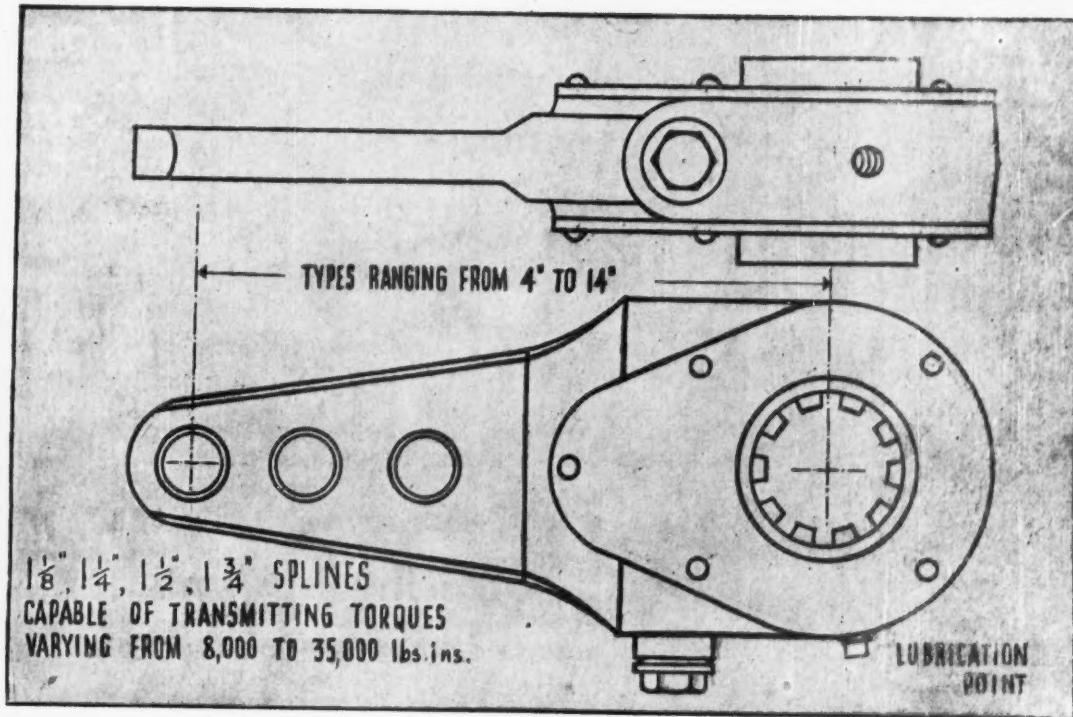
CLAYTON DEWANDRE

NEW TYPE SLACK ADJUSTER



which provides most accurate brake adjustment with speed and ease. Made in varying styles and arm lengths suitable for cam operated brakes. Strictly interchangeable in detail with the world renowned

Bendix-Westinghouse SLACK ADJUSTER



CLAYTON DEWANDRE CO. LTD. *Lincoln*

NORAL ALLOYS



As competition returns to the motor industry's home market, designers of mass-produced cars will start thinking seriously about aluminium for coachwork.

From the beginning it has been used for the bodywork of luxury cars and sports models, and its durability is proved by the excellent condition of the many old aluminium-bodied cars still on the road.

In recent years considerable experience has been gained with aluminium body pressings and manufacturers will be able

to put this to good account when discerning motorists are again able to choose freely.

We shall be glad to give, without obligation, specific advice on any application of Noral alloys.

NORAL
Northern Aluminium
COMPANY LIMITED

An ALUMINIUM LIMITED Company



MAKERS OF NORAL SHEET, STRIP, PLATE, SECTIONS, TUBING, WIRE, FORGINGS, CASTINGS, ALPASTE FOR PAINT
SALES DEVELOPMENT DIVISION: BANBURY, OXON

SALES OFFICES: LONDON, BIRMINGHAM, MANCHESTER, BRISTOL, NEWCASTLE-ON-TYNE, LEEDS



I don't give two hoots for your Owl Patrol,
said the M.D. testily. My little lot have
won more badges for drilling in odd corners,
screwing up the inscrutable, nut running, gun
running, rum running and showing old ladies
under buses . . . Good turns? Me newest
tenderfoot does them at the rate of 1,000 a
minute.* I am happy, nay proud, to be
their dear old scout master —

'Old master is right', said a little horror
in very long shorts. At least that's
what we thought he said.

* The old boy seems to be referring to the latest Desoutter straight drill, a $\frac{1}{2}$ " model weighing only half as much as other tools of similar capacity, with speeds of 1,000, 550 and 370 r.p.m.

'Morse, of course', said the Little Horse.

— • / • / • • / — — — / • • — / — / — / • / — • *tools*
put power into your hands

Desoutter Bros., Limited, The Hyde, Hendon, London, N.W.9. Telephone Colindale 6346 (five lines) Telegrams: Despnuco, Hyde, London.
CRC 249



.....headline in Production
Engineering & Management
January, 1953

"FORD HOBS GEARS 350% FASTER"

We've checked on it and the editors of PRODUCTION ENGINEERING & MANAGEMENT are right. At Ford Motor Company, U.S.A. 3½" diameter, 9-pitch, 1½" face width transmission gears are being hobbed at a production rate 350% greater per spindle than compared with multiple spindle machines. To do this Ford uses one of the new Michigan Ultra-Speed gear hobs equipped with double thread accurate unground Michigan hobs. Gears are hobbed two at a time, 58 seconds per pair.

Despite the high output rate, 225 gears are produced per sharpening of the hob. Among the reasons given are that "the machine is of rugged, compact construction, simplified in design, with few gears for the index and main drive and . . . with a maximum spindle speed of 1000 r.p.m."

Of interest is that better control of surface finish is obtained by easier subsequent shaving. Loading and unloading time is kept to a minimum by hydraulically-actuated expanding arbors. Vibration has been practically eliminated by providing maximum rigidity plus a flywheel to dampen torsional vibration.

For further details, write for Bulletin #1458-52.

GEAR PRODUCTION HEADQUARTERS.

GASTON E. MARBAIX LTD

DEVONSHIRE HOUSE, VICARAGE CRESCENT, BATTERSEA,
LONDON, S.W.11

SALES AND SERVICE ENGINEERS TO



For high output . . .



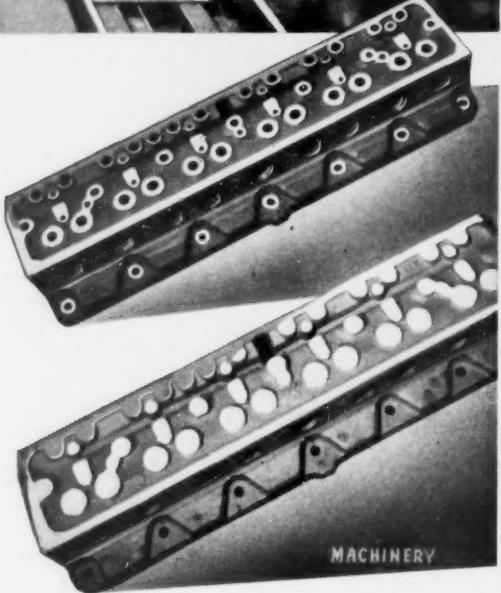
ON "BEDFORD" CYLINDER
HEADS VAUXHALL USE . . .

ARCHDALE *Specials*

By courtesy of VAUXHALL MOTORS LTD., LUTON, we illustrate a special ARCHDALE machine for performing drilling, reaming, counter-boring and tapping operations on cylinder heads in an automatic, continuous sequence.

Developing such machines is a speciality of the ARCHDALE organisation, and the machine illustrated is only one of hundreds of special machines, including transfer machines, supplied to the automobile industry.

Our experienced technical staff will be pleased to co-operate with you on any problems connected with drilling, milling or allied operations.



JAS. ARCHDALE & CO., LTD. BIRMINGHAM, 16
TELEPHONE: EDBGASTON 2276 (5 LINES) TELEGRAMS: ARCHDALE, BIRMINGHAM.

SOLE SELLING AGENTS: ALFRED HERBERT LTD. COVENTRY.

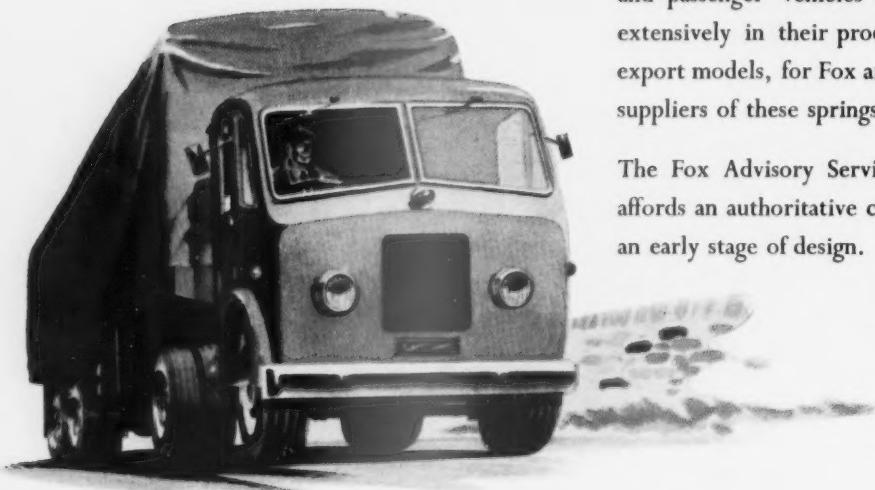
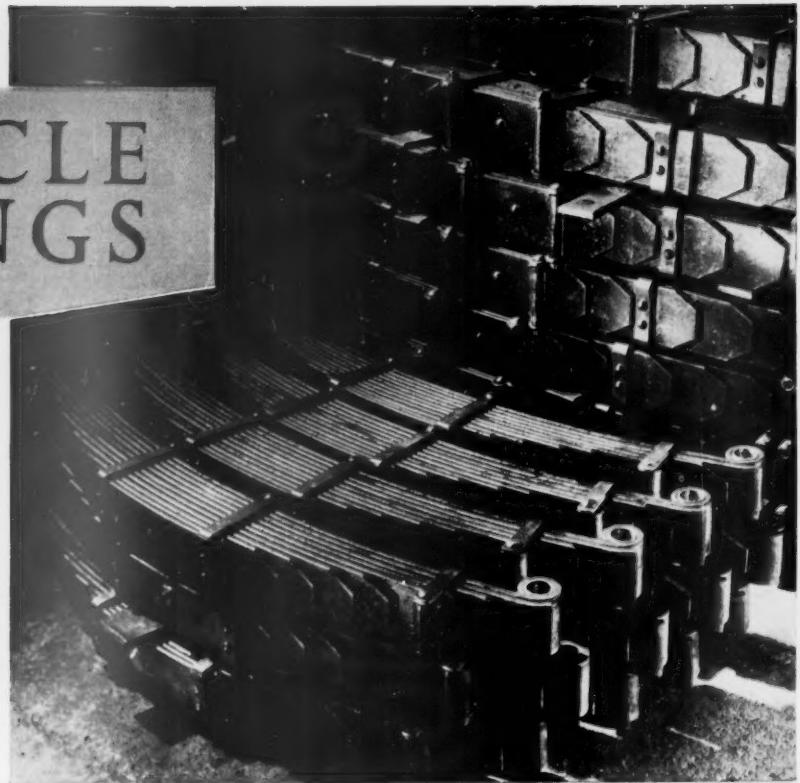
Moulded Camshafts

PAR EXCELLENCE



THE MIDLAND MOTOR CYLINDER CO. LTD., SMETHWICK, STAFFS.

VEHICLE SPRINGS



Manufacturers of British heavy commercial and passenger vehicles employ Fox Springs extensively in their production for home and export models, for Fox are amongst the largest suppliers of these springs.

The Fox Advisory Service for spring design affords an authoritative consultative service at an early stage of design.

THE UNITED
STEEL
COMPANIES LTD

SAMUEL FOX & COMPANY LIMITED

Associated with The United Steel Companies Limited
STOCKSBRIDGE WORKS · Near SHEFFIELD

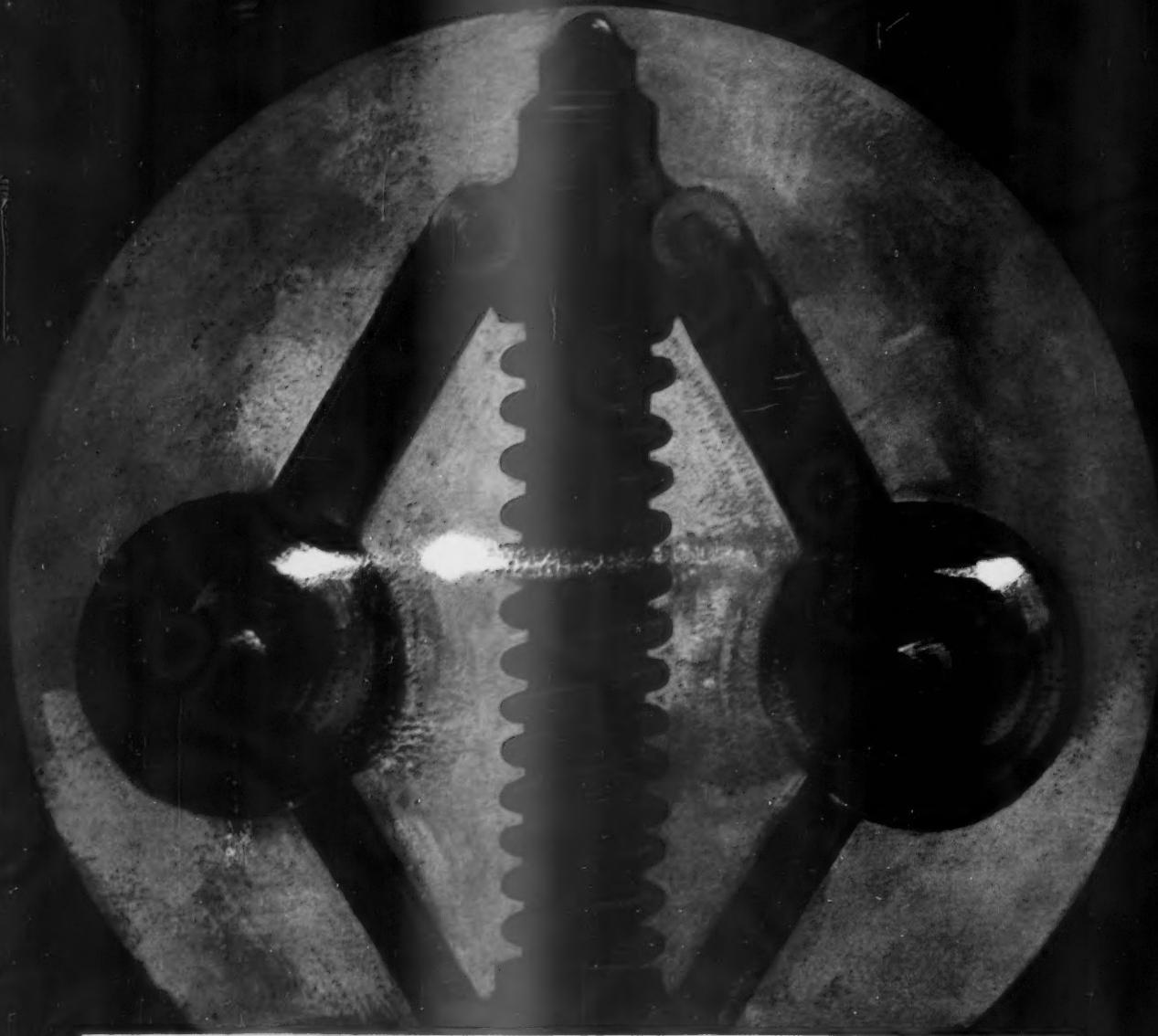
COVENTRY MOTOR FITTINGS

*Radiator Production
Specialists*

50 years experience of cooling design problems and quantity radiator production. Our Design Dept. is able at any time to put forward a suitable type of radiator or allied equipment for your special requirements.

**COVENTRY MOTOR
FITTINGS CO. LTD.
COVENTRY Tel. 5144/5.6.**

*Incorporating the C.M.F.
FLAT TUBE BLOCK*



ACCURATE SPEED CONTROL

The static friction which hampers the sensitivity of so many types of governor is eliminated in the Iso-Speedic governor by the use of flybobs consisting of hardened steel balls running on ground steel tracks.

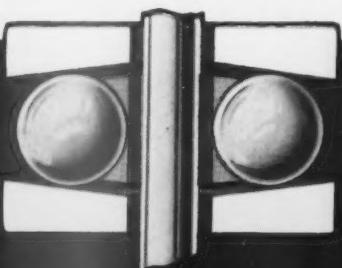
As a result, Iso-Speedic governors can be supplied which give control within 0.3 per cent and are used on generators for radar and television.

Other Iso-Speedic governors are available where a lower degree of accuracy is sufficient. Iso-Speedic governors are used on diesel engines and petrol engines and are available for other speed control applications.

The services of our engineers are at your disposal.

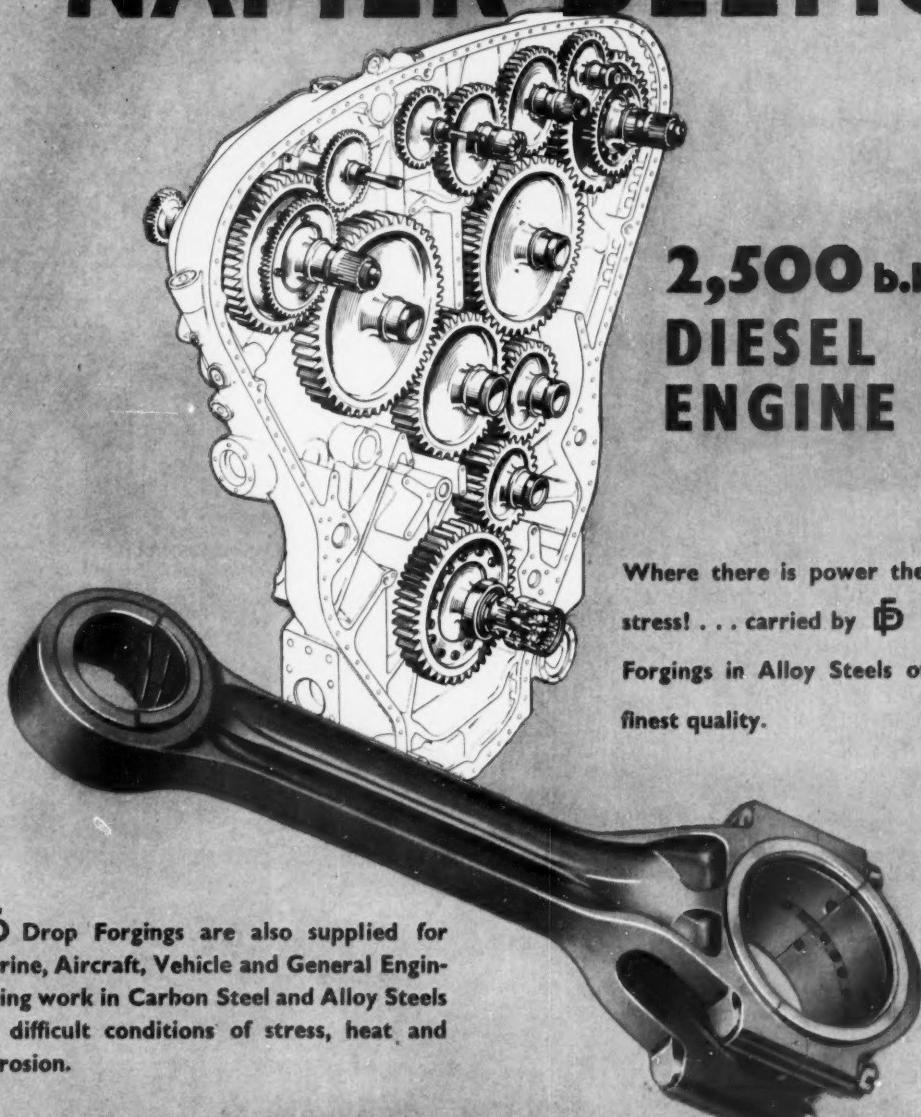
THE ISO-SPEEDIC COMPANY LIMITED, COVENTRY

Iso-Speedic



The

"NAPIER DELTIC"



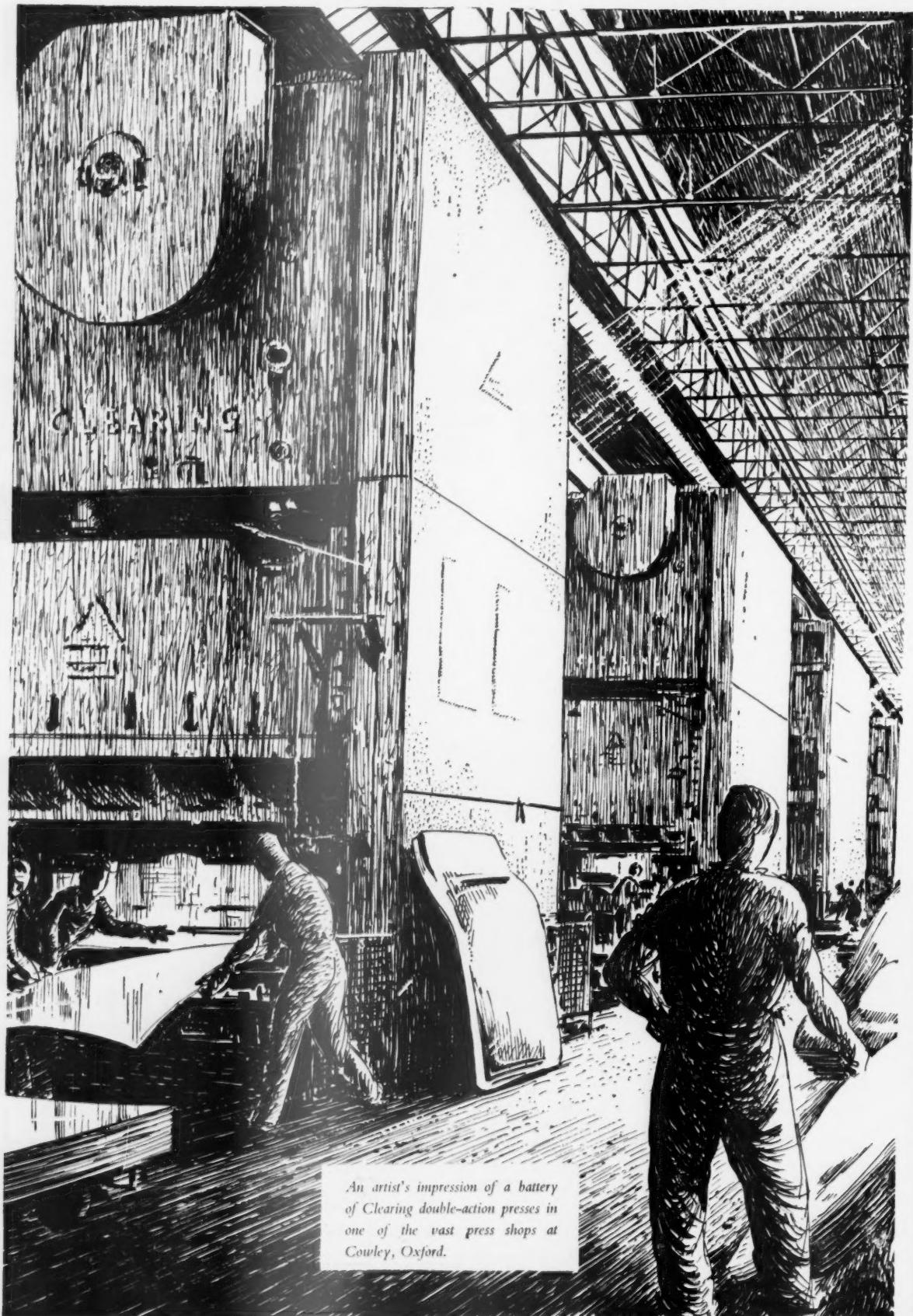
**2,500 b.h.p.
DIESEL
ENGINE**

Where there is power there is
stress! . . . carried by  Drop
Forgings in Alloy Steels of the
finest quality.

 Drop Forgings are also supplied for
Marine, Aircraft, Vehicle and General Engin-
eering work in Carbon Steel and Alloy Steels
for difficult conditions of stress, heat and
corrosion.

FIRTH-DERIHON DROP FORGINGS

THE FIRTH-DERIHON STAMPINGS LTD • TINSLEY • SHEFFIELD



An artist's impression of a battery of Clearing double-action presses in one of the vast press shops at Cowley, Oxford.

"The largest press shops in Europe, with over 350 power presses working with pressures up to 1,000 tons... a factory area at Cowley alone more than half the size of Hyde Park... Here, indeed, with its 12,000 and more workers, is one of Britain's greatest industrial enterprises."

cars in the making

FROM THESE IMMENSE presses come bodywork and pressings for many of the most famous names in the British motor-car industry, including Austin, Daimler, Hillman, Humber, Jaguar, Lanchester, Morris, Morris Commercial, M.G., Riley, Rover, Singer, Wolseley.

Pressed Steel Company Limited are the largest car body manufacturers in Britain and pioneers in this country both of pressed steel bodywork and unitary construction in quantity. The unequalled service of the Company to the British motor-car industry is founded on engineering and production facilities second to none, an organisation without parallel in Britain, and unsurpassed technical experience.

In its continued — and continual — expansion this service will, also, not be denied to manufacturers yet to achieve world renown.

PRESSED STEEL COMPANY LIMITED



*Manufacturers also of Prestcold Refrigerators, Steel Railway Wagons,
Agricultural Implements and Pressings of all types.*

FACTORIES: COWLEY, OXFORD. THEALE, BERKSHIRE. LINWOOD, SCOTLAND.

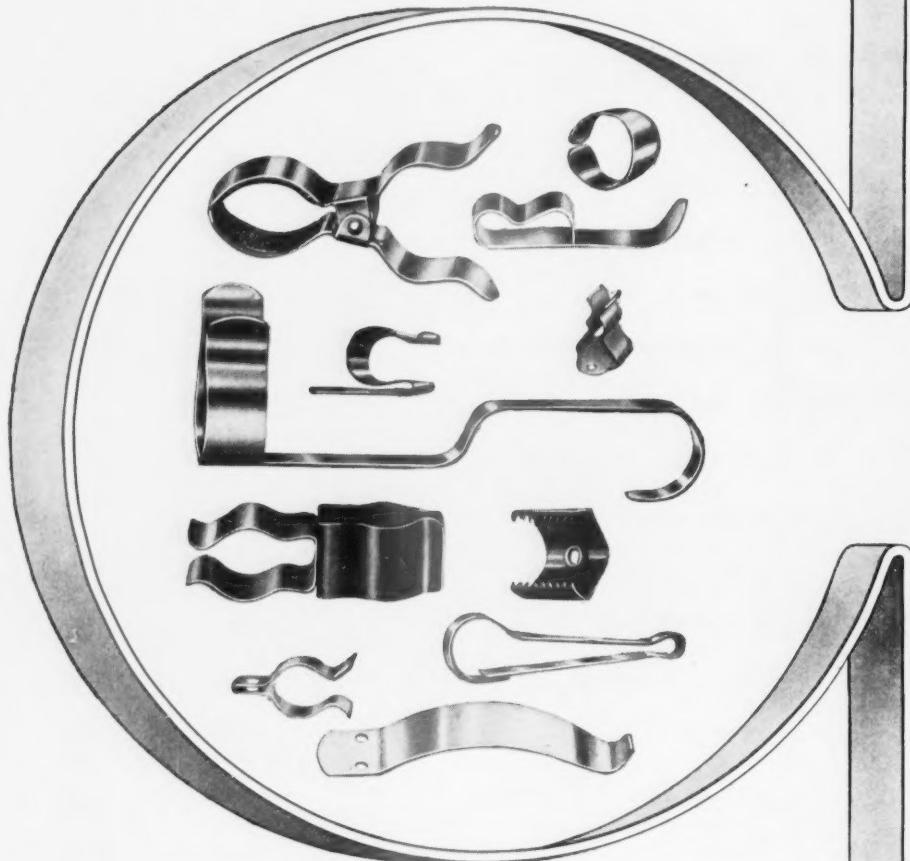
HEAD OFFICE: COWLEY.

LONDON OFFICE: SCEPTRE HOUSE, 169 REGENT STREET, W.I.

How are you fixed for CLIPS?

If you are having trouble with clips, bring your problem to us. We show here a few varieties, but these, mark you, are only a **very** small selection from our range of thousands of CLIPS... in every possible shape, size and quantity — in phosphor-bronze, brass, steel, stainless, plated... for every trade and profession.

And if you want a 'special' let TERRY'S Research Department design for you — after all, we've got 98 years' experience behind us.



and 5 very popular 'numbers'

80 and 81 — general utility clips — for tool racks, etc., from $\frac{1}{2}$ " to 2" from stock.



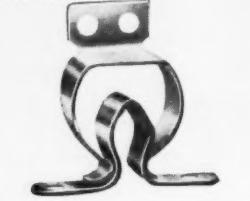
300 — an exceptionally efficient drawing board clip, 5/- a doz. (inc. p.t.) from stock.



257 — a useful clip in black enamel, from $\frac{3}{8}$ " to $1\frac{1}{2}$ ".



1364 — a clip for kitchen cabinets — rustproof finish.



Really interested in springs? This book — **Spring Design and Calculations** — packed from cover to cover with spring data, is yours post free for 12/6.



kollercast



SHELL MOULDING RESIN

This shell moulding resin is a REICHHOLD product. It is a pure phenolic resin (cresol free) used extensively in foundry practice in America and in Europe. To our own considerable experience in this highly specialised field of resin chemistry is added that of our American and European Associates. We are therefore at an advantage in offering the Services of our Technical Service staff for discussion and the facilities of our Service laboratories for work in the solution of problems connected with the development of casting by the shell moulding process. We welcome active co-operation with British foundries.



BECK KOLLER & CO (ENGLAND) LTD

BECKACITE HOUSE, SPEKE, LIVERPOOL 19

• Associate Works: Reichhold Chemicals Inc., Detroit, U.S.A.

Samples and details available from the Sole Selling Agents



JAMES BEADEL & CO. LTD, Head Office: Speke, Liverpool 19. London Office: 110 Cannon Street, E.C.4.

Detachable oil filter



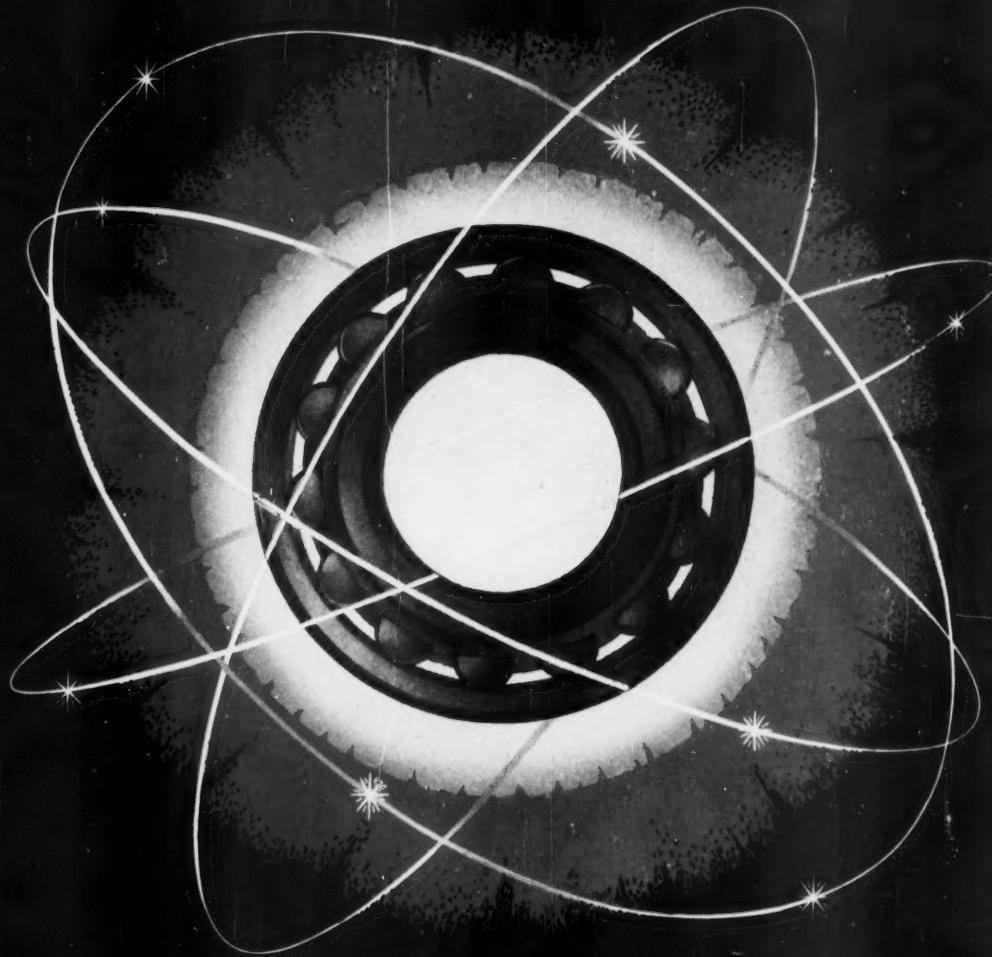
This new AC partial-flow oil filter with replaceable element meets the increasing demand for a filter that can be removed for inspection and replaced every 8/10,000 miles. It provides a permanent installation for coupling into a by-pass oil supply system and the filtering element can be replaced without disturbing pipe connections. Sump oil is filtered on an average of ten times an hour. This means less motor wear and longer motor life — the objective of every motor manufacturer.



AIR CLEANERS • AIR SILENCERS • CRANKCASE
BREATHERS • CAR HEATERS • FUEL PUMPS
SPEEDOMETERS • GAUGES • INSTRUMENT PANELS
OIL FILTERS • THERMOSTATS • SPARK PLUGS
WINDSCREEN WIPERS • DIE CASTING

We'll gladly help when you plan a new design or modify an existing one. Write to:
AC Technical Bureau, 54 The Butts, Coventry; or 'phone Coventry 61747.

AC-DELCO DIVISION OF GENERAL
MOTORS LTD., DUNSTABLE, BEDS.
and Southampton, Hants.



*Always specify
R&M Bearings*

The rapid progress made in British atomic research owes much to trustworthy, enterprising equipment.

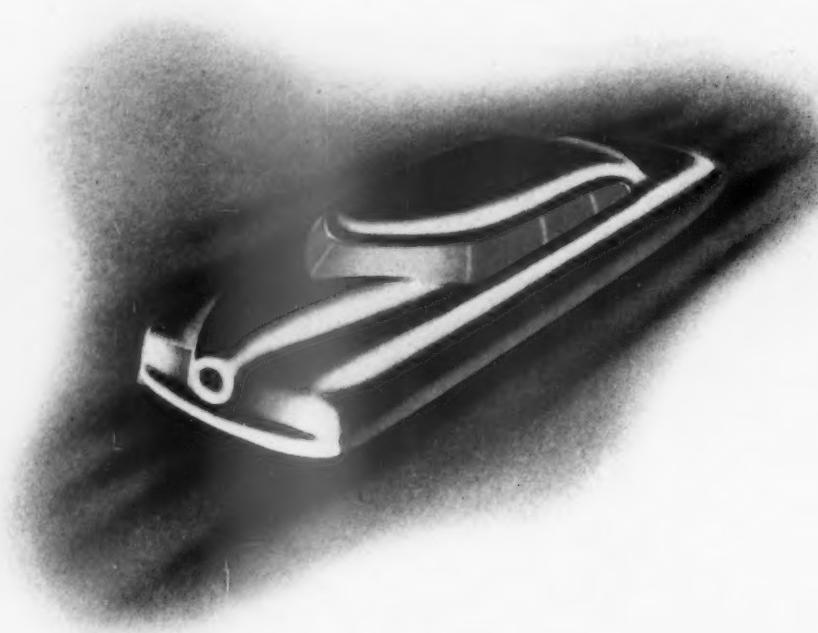
Essential components wherever there are moving parts, R&M Bearings will ensure smooth, frictionless running and withstand high speeds, acceleration, heat, pressure and other intense stresses.

The trouble-free service they give in such arduous conditions is a tribute to the fine materials and careful workmanship that characterise their manufacture.



RANSOME & MARLES BEARING CO., LTD.,

* NEWARK-ON-TRENT, ENGLAND. *



*Whatever the shape
to be sure
you will use . . .*

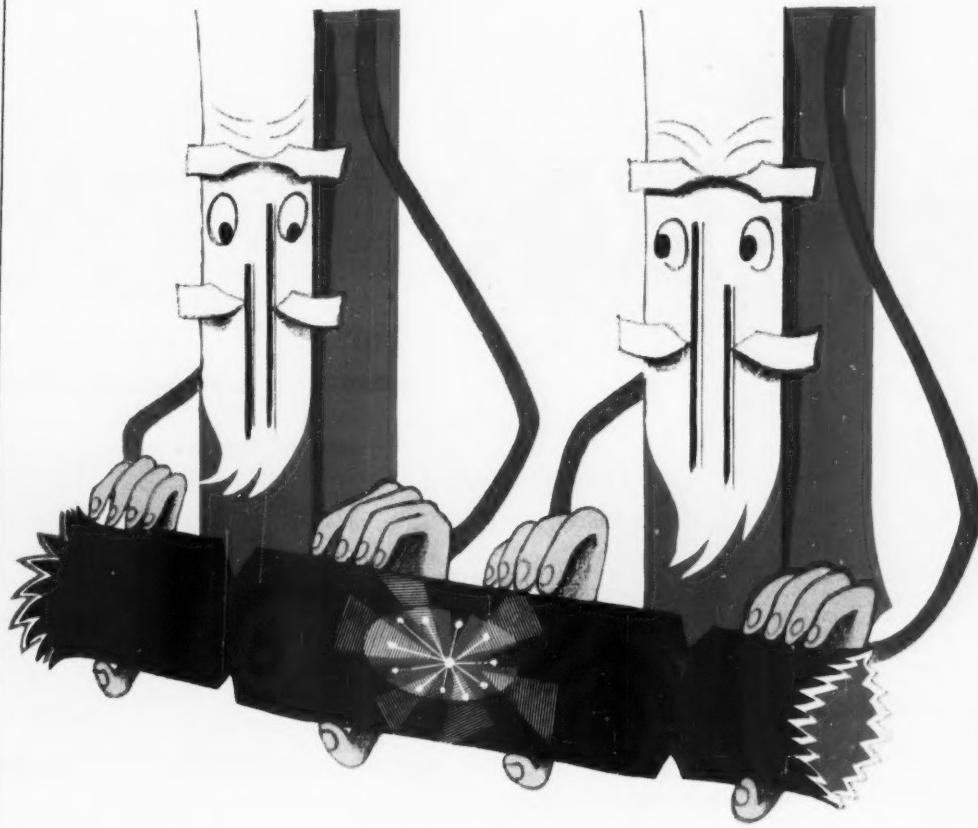


Smethwick Drop Forgings

SMETHWICK DROP FORGINGS LTD.



SMETHWICK & KIDDERMINSTER, ENG.

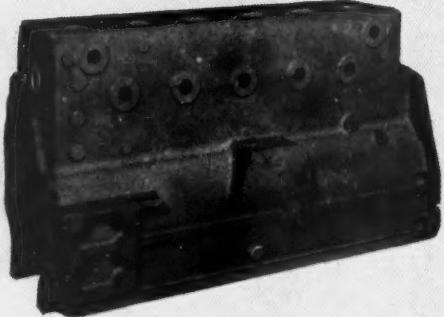
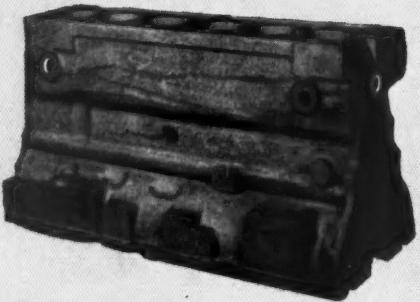
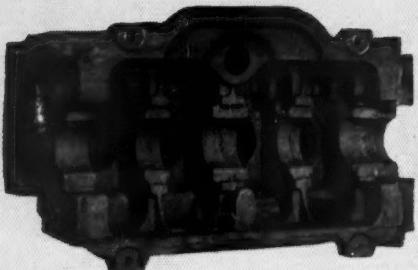


*Surely, for Christmas time, we should invent
Some gastronomic gauge, Comparator or Jet,
Which would discreetly take the measurement
Of all the food we — well but so unwisely — ate.*

Solex Gauges wish you a happy Christmas and a Prosperous New Year



We take CARE
to start you
right!



All castings that leave the West Yorkshire Foundry are, in a sense, a step ahead of themselves. Not only are they structurally and metallurgically perfect, but each one is accurately checked to pre-machined locations *in the foundry*, all ready for the first milling operation. The solicitous care that we at West Yorkshire give every job ensures that all our castings machine up correctly ; setting times and machine shop scrap are substantially reduced. Our modern equipment is planned for quantity production of top grade castings in high-duty iron and aluminium alloys. We think that we can always show a saving both in first cost and machine shop costs. Why not ask us to estimate for *your* work ?

Some users of West Yorkshire castings:—

**ALBION • AUSTIN • HUMBER • JAGUAR • LEYLAND • PERKINS
ROLLS-ROYCE • ROVER • SUTCLIFFES • ETC.**

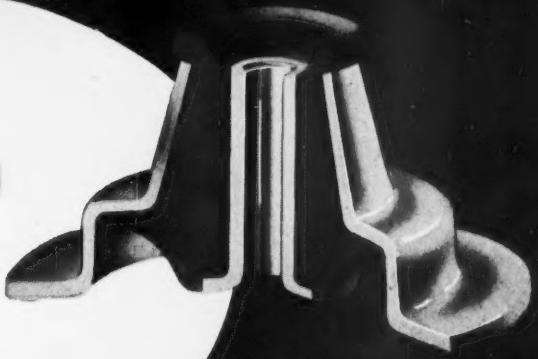
WEST YORKSHIRE FOUNDRIES LTD

SAYNER LANE, LEEDS 10 Telephone LEEDS 29464-7-0

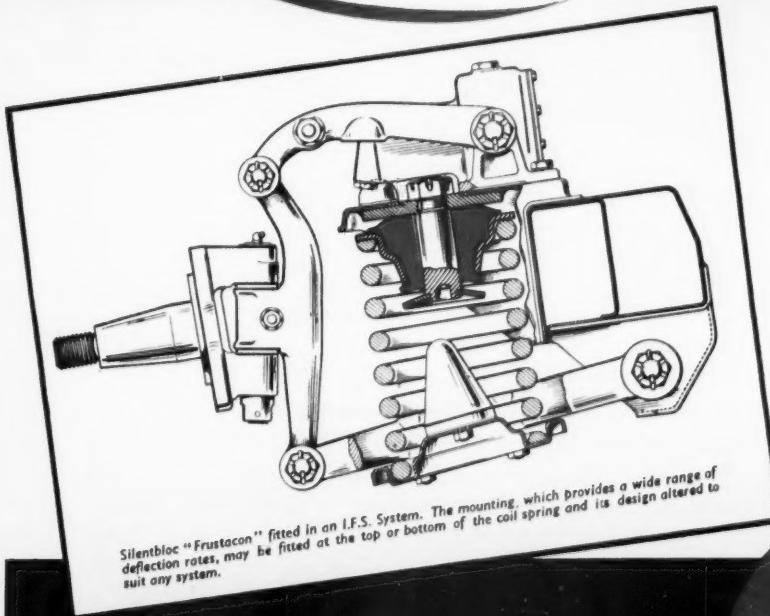
MANOR HOUSE, MANOR SQUARE, LONDON, W.C.2

Silentbloc FRUSTACON..

... the first
scientifically designed
flexible mounting
fitted to the
I.F.S. of a Production Car



The 'Frustacon' mounting fitted to
the I.F.S. of the 1952 Rover '75'.
Sectioned to show rubber.



Silentbloc "Frustacon" fitted in an I.F.S. System. The mounting, which provides a wide range of deflection rates, may be fitted at the top or bottom of the coil spring and its design altered to suit any system.

SILENTBLOC LTD.
VICTORIA GARDENS
LONDON, W. II.

TEL. PARK 9821





A UNIT OF ACHESON
INDUSTRIES INC.



HIGH TEMPERATURE LUBRICATION

Bearings of oven cars, kiln cars, lehr conveyors and all equipment subject to high temperatures can be properly lubricated only with 'dag' colloidal graphite.

A thin, durable layer, obtained on almost any surface by simple application of a 'dag' dispersion, provides effective lubrication up to and above 1000° C.

No sticking, no fumes, no coking—you cannot afford to ignore this important, up-to-date, high temperature lubricant.



Act now write today for full technical information available free from:

ACHESON COLLOIDS LIMITED
18 PALL MALL, LONDON, S.W.1.
Phone: WHItchall 2034/7 Grams: OILDAG, PICCY, LONDON
also ACHESON COLLOIDS COMPANY, Port Huron, Mich., U.S.A.

dag
REGD. TRADE MARK
DISPERSIONS

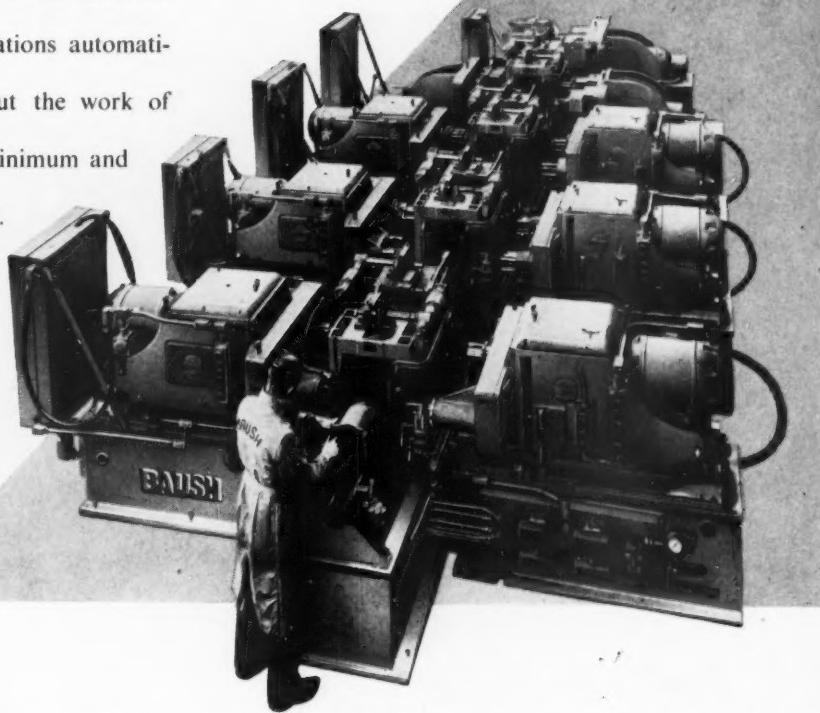
TAS/AC34

BAUSH TRANSFER LINEUP

gives maximum production with a minimum of labour

Today Baush-designed multi-unit transfers are performing hundreds of operations automatically—one operator turns out the work of many—costs are held to a minimum and production is greatly increased.

Why not send us your prints and specifications—there's no obligation and we may save you many costly manpower hours. Phone, wire or write us today.



The four 2-way horizontal and one single way horizontal hydraulic machines—each with one load and two work stations, as illustrated, are a part of a complete transfer lineup designed to perform all machine operations on automotive transmission cases for a large American plant. With a production schedule of 80 automotive transmission cases per hour this lineup drills, reams, counterbores, countersinks, rough bores, semi-finish bores and taps holes in both the single and double bore sides of case. Automatic turnover fixture is provided, prior to last machine in lineup, to index case into exact position for tapping all holes in bottom face.

Sole Agents



The Selson Machine Tool Co. Ltd

CUNARD WORKS, CHASE ROAD, NORTH ACTON, LONDON, N.W.10
Telephone: Elgar 4000 (10 lines) Telegrams: Selsomachi, London



524/SMT9

CEJ



CEJ TAPS

Spiral Flute Taps for blind hole tapping. Spiral Point Taps for through hole tapping. In each case only one tap is needed.



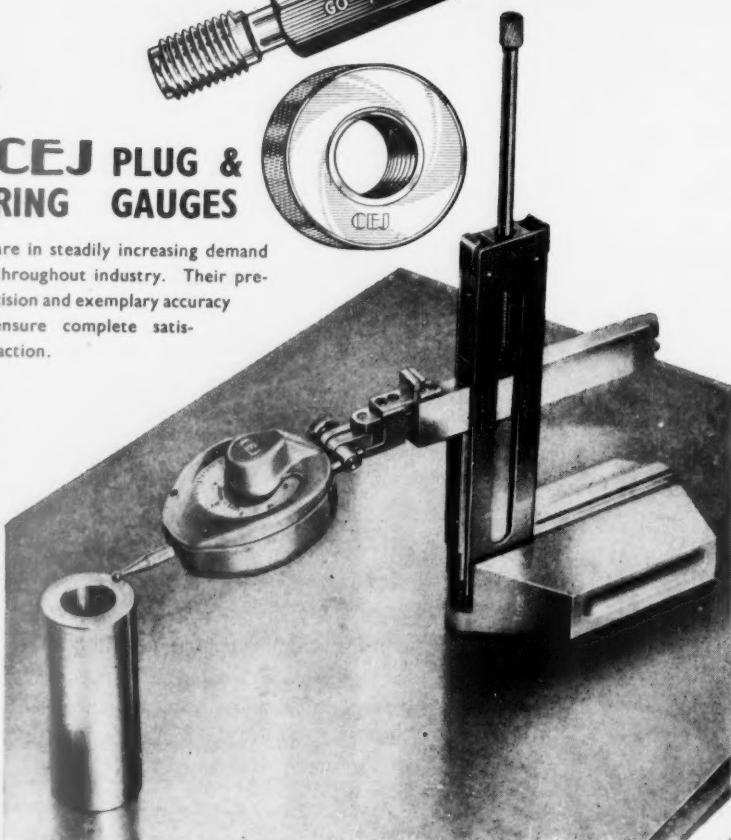
CEJ PLUG & RING GAUGES

are in steadily increasing demand throughout industry. Their precision and exemplary accuracy ensure complete satisfaction.



CEJ CIRCULAR CHASERS

for producing outside and inside threads in all forms



CEJ Minikator

A micro-indicator especially designed for transferring dimensions and particularly suitable for indicating out-of-roundness or concentricity of machine spindles and for setting up components. Twisted strip amplification purely mechanical, without friction or slackness. Two measuring points supplied with every instrument. One providing a measurement range of .003" with .00005" dial graduations, the other providing a range of .006" with .0001" dial graduations. The illustration shows the Minikator being used in the CEJ Gauge Block holder and base.

CEJ JOHANSSON LTD.

PRECISION TOOLS AND INSTRUMENTS

A.I.D. APPROVED

SOUTHFIELDS ROAD, DUNSTABLE, BEDS

TEL: DUNSTABLE 422/3

DHB

COOPERS

GASKETS. FILTERS & STRAINERS

It is our business to know all
there is to know about Gaskets
Filters and Strainers and to put
that knowledge into practice.



COOPERS MECHANICAL JOINERY LTD.

LLANFOIST WORKS, ABERGAVENNY, MON.

Telephone: Abergavenny 550.

HEAD OFFICE

LIVERPOOL ROAD, SLough, BUCKS.

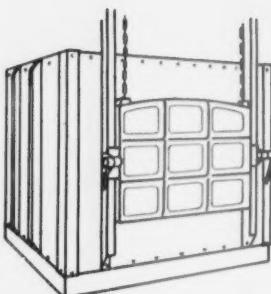
Cogent

Order now!

**STANDARD ELECTRIC
FURNACES**

by

G.E.C.



HORIZONTAL BATCH TYPE



FORCED AIR CIRCULATION TYPE

Your needs will receive
immediate attention

THE GENERAL ELECTRIC CO. LTD., MAGNET HOUSE, KINGSWAY, LONDON, W.C.2

LEY'S

Europe's largest malleable producers

Ease of machining is just as characteristic of Ley's 'Black Heart' malleable castings as their strength and rigidity. Ley's castings are being used more extensively for exacting requirements.

The illustration shows a rear axle housing for a famous automobile, with special cored lubrication passages.

LEY'S 'BLACK HEART' MALLEABLE CASTINGS:

Elongation :

18%

Yield Point :

16 tons p.s.i.

Tensile strength :

24 tons p.s.i.

LEY'S 'LEPAZ' MALLEABLE CASTINGS:

6%

Yield Point : 21 tons p.s.i.

Tensile strength : 35 tons p.s.i.

We offer your designers the full collaboration of our engineers.

LEY'S MALLEABLE CASTINGS COMPANY LIMITED, DERBY
TELEPHONE: DERBY 45671

Strength
Rigidity



LEY'S

ANNOUNCING A NEW

HIGH

FRICITION

MOULDED

HEAVY DUTY

BRAKE LINING

CAPASCO

MOULDED BRAKE LININGS



The Cape Asbestos Co. Ltd., 114-116 Park Street, London, W.I. Tel: GROsvenor 6022

Capasco

H.F.7

With all the proved stability and non-fade properties
of the well known moulded range.

Write for full particulars to:-



The Cape Asbestos Co. Ltd., 114-116 Park Street, London, W.I. Tel: GROsvenor 6022



Meet a tough baby!



UNBRAKO HIGH TENSILE STEEL SOCKET SET SCREW 6 B.A. $\times \frac{1}{4}$ "



HIGH TENSILE STEEL SOCKET SET SCREW $\frac{1}{4}'' \times 4''$

Whenever
you meet an
Unbrako Socket Screw
whatever its size
you are meeting
something
tough.

Available for immediate delivery.
Send for free samples.

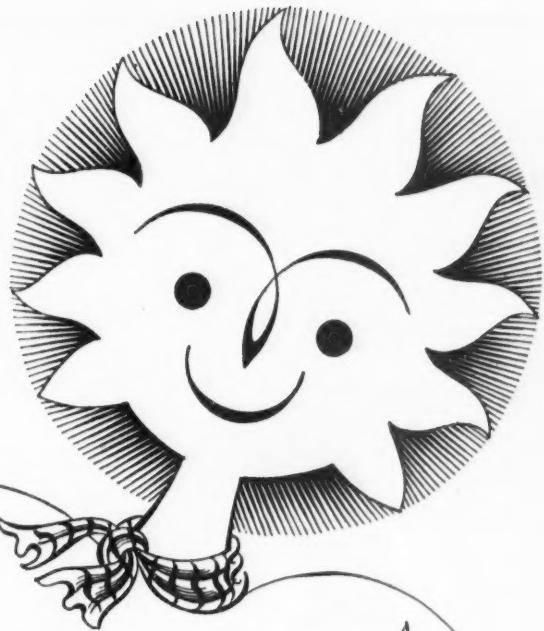
UNBRAKO SOCKET SCREW CO. LTD.

*Manufacturers of Unbrako standard socket screws
and special screws to A.I.D. requirements.
Please send us your enquiries.*

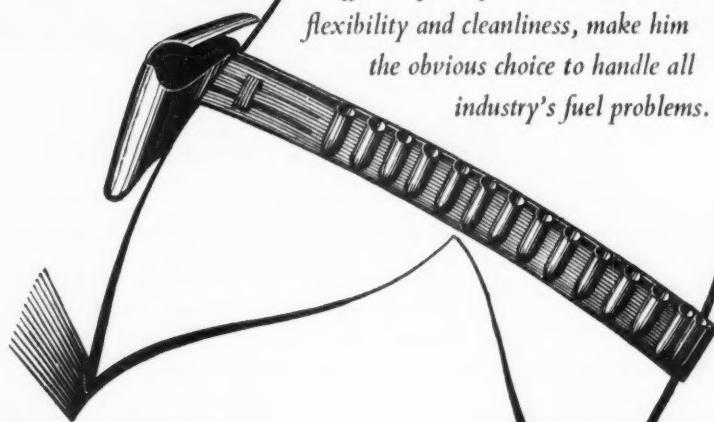
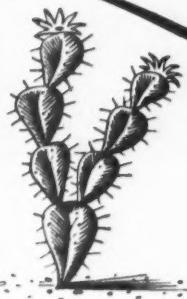
COVENTRY

ENGLAND

I go
into action
fast



Gas never keeps you waiting — dead-on controls deliver exactly the heat required, instantly. And the heat can be turned off just as quickly when the job's done. Since warming-up and cooling-off are eliminated, gas saves both time and fuel. Gas needs little attention—with automatic controls it can be left to do many jobs for you. Mr. Therm's remarkable efficiency, coupled with his unusual flexibility and cleanliness, make him the obvious choice to handle all industry's fuel problems.



Mr. Therm
burns to serve you



Mr. THERM IN
GENERAL
ENGINEERING

Among the great variety of uses of gas are: general heat treatment, flame hardening, annealing, tempering, case hardening, normalising, preheating, metal melting, core drying, forging, brazing, soldering, oxy-tow gas cutting, steam raising, water and space heating.

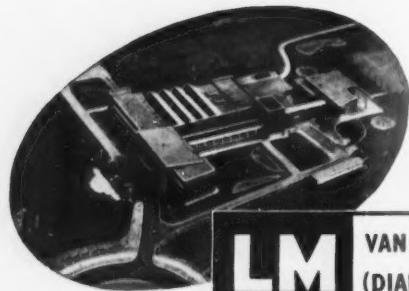
THE GAS COUNCIL • 1 GROSVENOR PLACE • LONDON • SW1



timed finish

Modern watch-cases require high standards of finish combined with low manufacturing costs.

The Diatipt tools illustrated, used with a plunge cut, produce the final finish without tool marks at high production rates.



LM

VAN MOPPES & SONS
(DIAMOND TOOLS) LTD

BASINGSTOKE · HAMPSHIRE · BASINGSTOKE 1240

TRADE MARKS · DIATIPT · DIADUST · DIATRU · DIANYF · DIATUF · DIAFORM · DIADEX

Folksain-
Wycliffe
FOUNDRIES LTD

for Reliable Castings

IN BLACKHEART MALLEABLE



A group of typical castings in regular production

Founded in 1906 and suppliers to the Motor Trade for over 40 years. Pioneers in the use of Rotary furnaces. Laboratory controlled throughout. Notable for accuracy, reliability and easy machinability. We have our own machine shop and castings can be supplied fully machined if desired.

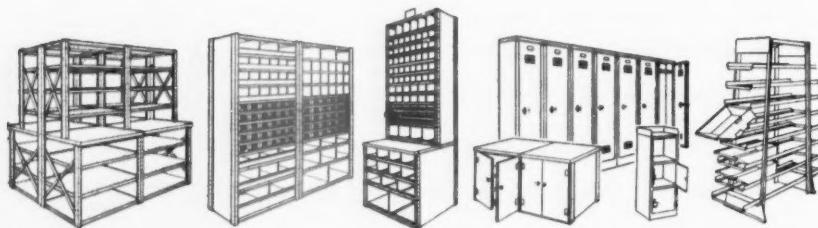
FOLKSAIN-WYCLIFFE FOUNDRIES LTD., LUTTERWORTH
Nr. Rugby. Tel. Lutterworth 10 & 60



ARE YOU ORGANISED?

Accessibility is the keynote of Stores Layout. Versatility too is a pre-requisite. The same system must serve as efficiently for 'small screws as for heavy components. R.O. Steel Shelving and Binnage is universally applicable and is supplied ready for quick and easy assembly on site.

Our storage experts will advise on the choice of a single piece of equipment or co-operate in the design of a complete installation.



ADJUSTABLE SHELVING & BINNAGE

LOCKERS

CUPBOARDS

RACKS

RUBERY OWEN STORAGE EQUIPMENT



RUBERY, OWEN & CO. LTD., Industrial Storage Equipment Division, Whitegate,
Wrexham, North Wales.

Telephone : Wrexham 3566.

Member of the Owen Organisation

the things they do at Holroyd's

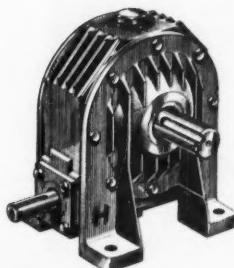


They make their wheel teeth and worm threads in something they call 'basic involute helicoid form, modified to give oil entry gap at contact lines'. They say this gives correct contact and oil film lubrication in fully loaded and deflected positions. They say this helps to make their worms and wheels the very good worms and wheels that they are. Any questions?

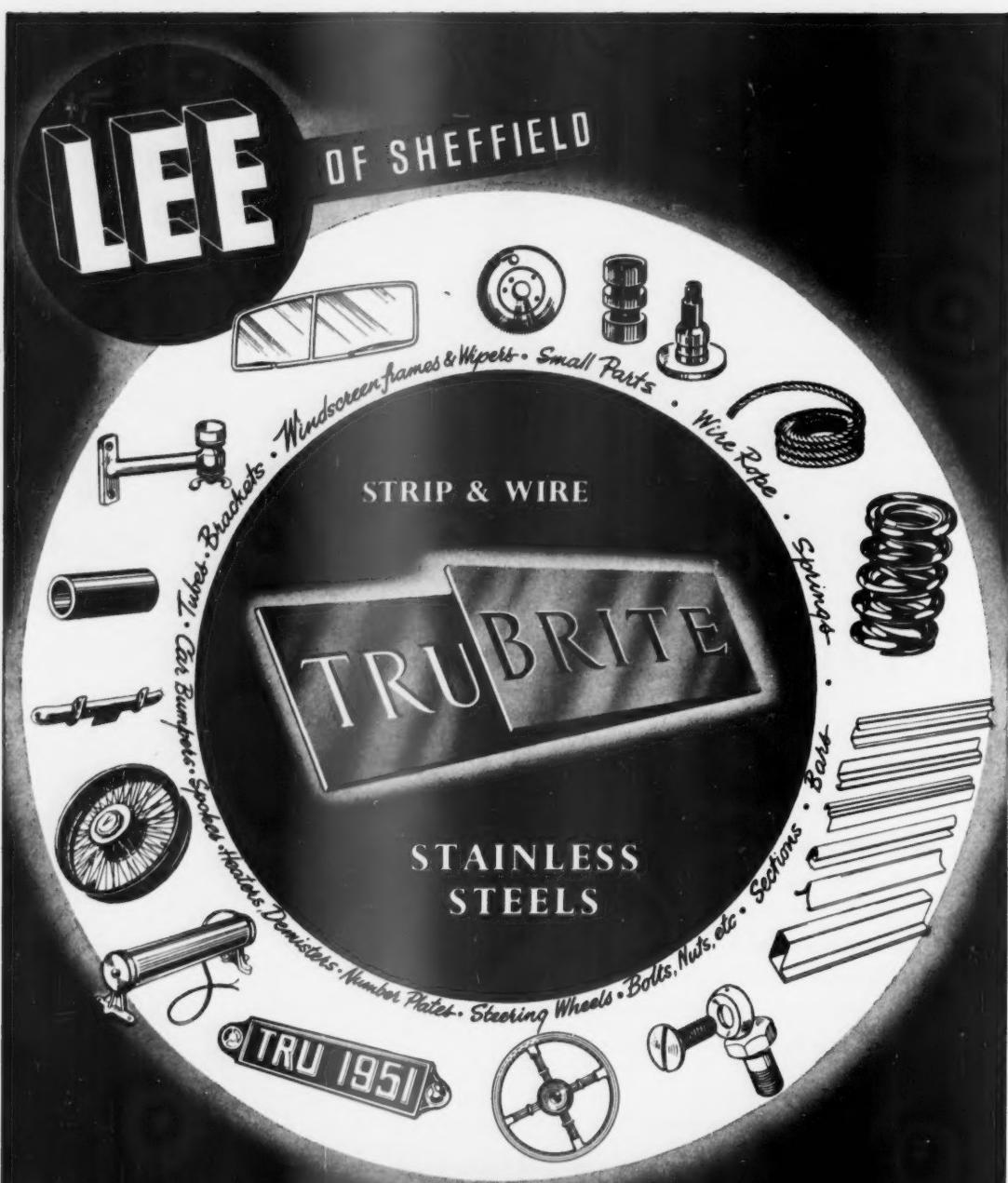
They've written a book about it —

about the way they make their worms and wheels, about gear selection and service, dimensions, efficiencies, lubrication and maintenance — all the facts a user needs on Holroyd Worm Gears and Worm Reduction Units.

They'll be very glad to send *you* a copy. Their address is John Holroyd & Co. Ltd., Milnrow, Lancs.



QUICK DELIVERIES CAN BE MADE OF ALL
Holroyd WORM GEARS AND WORM REDUCTION UNITS



The Motor Car Industry is another example of the ever increasing uses of "Trubrite" Stainless Steel in the form of Cold Rolled Strip and Wire, quite apart from the already well established uses of Bright Mild Carbon Steel Strip, Bright Steel Bars and High Strain Wires, with which we have for so long retained the confidence of Motor Car and Motor Accessory makers.

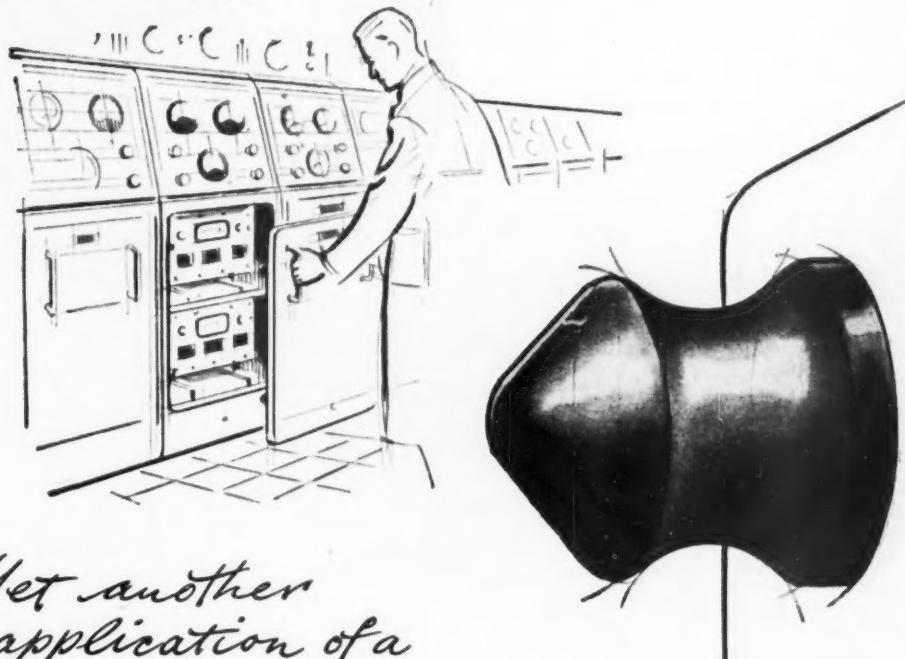
ARTHUR LEE & SONS LIMITED

"TRUBRITE" STEEL WORKS · MEADOW HALL · Nr. SHEFFIELD
ALSO AT CROWN WORKS, BESSEMER ROAD, SHEFFIELD 9

Phone : Sheffield 36931 (10 lines).

C 890-2

APPLICATION 100
SERIES 77



*Yet another
application of a*
"FLEXILANT"
BOLLARD
SERIES 77

THE "Flexilant" Bollard sprung into fame almost overnight. Anything to which they are fixed, in fact, becomes instantly and automatically attachable and detachable, the Bollard ensuring absolutely secure fixture which is, nevertheless, quite flexible and resistant to shock or vibration. We produce a range of components that absorb vibration; eliminate noise; suppress shock. Our new catalogue lists all these for you.

RUBBER BONDERS LIMITED

IN ASSOCIATION WITH EMPIRE RUBBER COMPANY (Proprietors: H.G. MILES LTD.)

DUNSTABLE . . . BEDFORDSHIRE

TELEPHONE DUNSTABLE 523-538 (4 LINES) TELEGRAMS: SPANDIT, DUNSTABLE



THE BEST STEEL FOR THE JOB

Our publication, "The Mechanical Properties of Nickel Alloy Steels" contains useful design data for a wide range of steels. Curves and tables of properties (such as these shown here) are given for 30 different direct-hardening and case-hardening nickel alloy steels, together with information on specifications and relationship between tensile strength, hardness, shear and torsional strengths.

This publication will assist the designer to choose the most suitable nickel alloy steel for any given purpose. Write for a free copy.

Tempering curves and table showing the properties obtainable with different heat-treatments and ruling sections for a low nickel-chromium-molybdenum steel to Specification En 110.

C	Mn	Ni	Cr	Mo	Chemical Composition per cent.	Tempering Temperature deg C	Size	Tensile Range Symbol	Heat-Treatment		Mechanical Tests				
									Harden °C	Temper °C	Y.P. f.t.l.	M.S. f.t.l.	Elong. per cent.	IZOD ft-lb	
0.37	0.67	1.38	1.15	0.15		14" dia. 14" dia. 14" dia.	W V U T	O.Q.840	560 590 620 650	70.3 65.2 58.8 52.8	74.3 69.8 66.3 60.2	17 20.5 21 23.5	35 56 64 70		
0.37	0.67	1.38	1.15	0.15		24" sq. 24" sq. 24" sq. 24" sq.	W V U T	O.Q.840	560 590 620 650	65.1 61.5 55.4 50.1	71.5 68 64 58.2	19 21 20 23.5	32 63 44 71		
0.37	0.67	1.38	1.15	0.15		4" sq. 4" sq. 4" sq. 4" sq.	V U T S	O.Q.840	560 590 620 650	61.7 55 51.5 48.6	68.8 62.9 60.2 56.8	19 20 21 24	32 65 74 88		
0.37	0.67	1.38	1.15	0.15		6" sq. 6" sq. 6" sq.	V U T S	O.Q.840	560 590 620 650	62.0 56.2 50.6 45.7	68.0 63.4 58.5 56.4	15.5 17.5 19.5 21.5	44 42 44 62		

THE MOND NICKEL COMPANY LIMITED • SUNDERLAND HOUSE • CURZON STREET • LONDON • W1

13/5/53

BRITAIN'S

2nd

nd

CITY

BECOMES ITS

st

IN MODERN PROGRESS

**BIRMINGHAM'S FAMOUS
MIDLAND RED
A new S.14 type
44 seater Public
Transport Vehicle—
and for the first time in
Passenger Transport history**

**fits
GIRLING**

THE BEST BRAKES IN THE WORLD

**DISC BRAKES
as standard equipment**



Way Out Ahead

GIRLING LTD · KINGS RD · TYSELEY · BIRMINGHAM 11

MOLYBDENUM HIGH SPEED STEELS

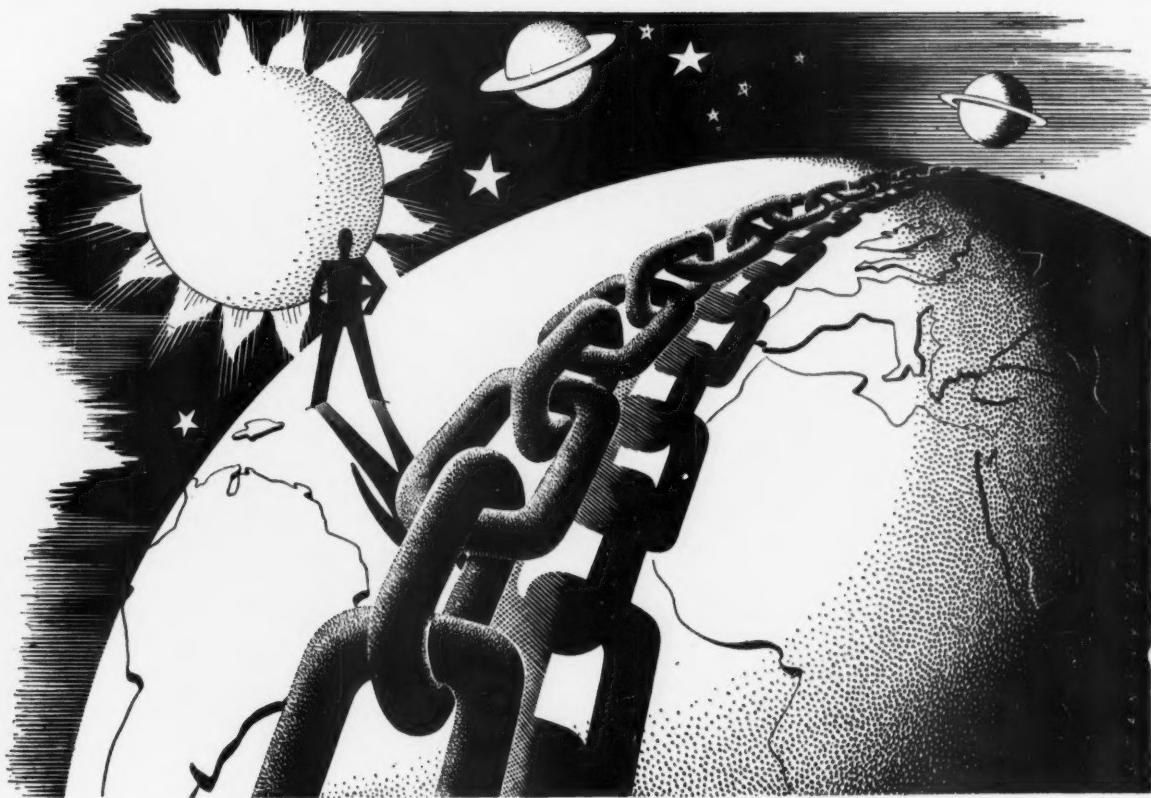
in world production
—now rapidly
overhauling
all other types . . .

Climax Molybdenum Company
MOLY

Technical Enquiries: 99 Pinstone St. Sheffield 1

Registered Office: 2-3 Crosby Square, London E.C.3

HS9



LINKS IN A WORLD-WIDE SERVICE

HOME SUBSIDIARY COMPANIES.

GEORGE COOPER & SONS.

Nuts, Bolts, Washers and Fastenings.

DARLINGTON RAILWAY PLANT & FOUNDRY CO. LTD.

Switches and Crossings, Railway Accessories.

DICK'S ASBESTOS AND INSULATING CO. LTD.

Asbestos Packings, Jointings and Insulation.

KETTON PORTLAND CEMENT CO. LTD.

Portland Cement and Kettton Freestone.

LOWNSOR BEST YORKSHIRE IRON LTD.

Wrought Iron Bars and Sections, Plates and Sheets.

MIDLAND IRON CO. LTD.

Wrought Iron and Steel Bars and Sections, Hoops and Strips.

NORTH LONSDALE TAR MACADAM LTD.

Road Construction Engineers and Contractors.

SHAN GRANITE CO. LTD.

Architectural Engineering Granite. Precast Concrete Products.

SILENT MACHINE & ENGINEERING CO.

Food Preparing Machinery.

JOHN SMITH (KEIGHLEY) LTD.

Overhead and Derrick Cranes. Stone Working Machinery.

THOMAS SMITH & SONS (RODLEY) LTD.

Steam, Electric and Diesel Cranes. Universal Excavators.

WIDNER FOUNDRY & ENGINEERING CO. LTD.

Castings and Constructional Steelwork for the Chemical, Oil, Food and allied Industries.

JOHN WILLIAMS (WISHAW) LTD.

Steel Plates and Sheets. Wire and Wire Products.

WOODHOUSE & MITCHELL.

Machine Tools.

OVERSEAS SUBSIDIARY COMPANIES.

THOS. W. WARD (BELGIUM) S.A.

8, Longue Rue des Claires, Antwerp.

THOS. W. WARD (INDIA) LTD.

Marshall Buildings, Ballard Road, Bombay

and 22, Brabourne Road, Calcutta.

THOS. W. WARD (SCANDINAVIA) A/B.

Birger Jarlsgatan, 131A, Stockholm.

S.E.B.I.M.

44, Ave de la Grande Armee, PARIS XVIIe.

THOS. W. WARD (AUSTRALIA) PTY LTD.

243, Castlereagh Street, Sydney, N.S.W.



The business founded by Thos. W. Ward in 1878 has grown from the smallest of small beginnings into a major commercial organisation with links throughout the entire industrial world.

Closely integrated with engineering and the heavier industries, the Ward Group of Companies produces many raw materials, manufactures a wide range of plant and machinery and provides at home, within the Commonwealth and throughout the world an infinite variety of general engineering products and services.

Link by link the chain has grown—purposefully, for service to industry—strengthened and annealed by 75 years' progressive experience.

THOS. W. WARD LTD

ALBION WORKS · SHEFFIELD

and

LONDON, GLASGOW, MANCHESTER, BIRMINGHAM,
LIVERPOOL, BRISTOL, GRAYS, WISHAW, PRESTON,
BARROW, BRITON FERRY, MIDDLESBROUGH, MILFORD
HAVEN and INVERKEITHING.



take out weight keep in strength!

..... by using wrought aluminium alloys in place of heavier traditional metals for the bodywork and fittings of road vehicles. And the saving is not one of weight only. The exceptional durability of these alloys means little or no maintenance and the long-term economy of dependable, trouble-free service.

Our Technical Service staff will be pleased to show you how 'Kynal' sheet, strip and extrusions can reduce costs and increase efficiency in your work.

'Kynal' wrought aluminium alloys are recommended for:-

Structural members

Roofing and panelling

Window frames

Tread strips

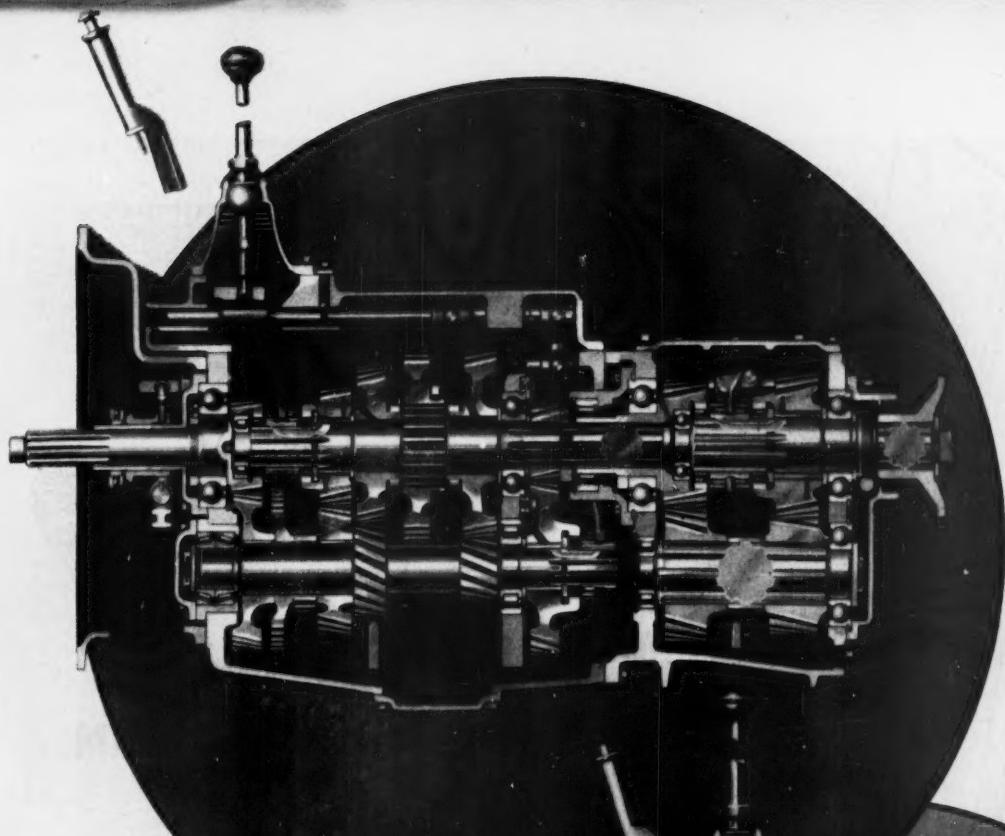
Doors

General small fittings.

'KYNAL' AND 'KYNALCORE' ALUMINIUM ALLOYS

IMPERIAL CHEMICAL INDUSTRIES LIMITED, LONDON, S.W.1

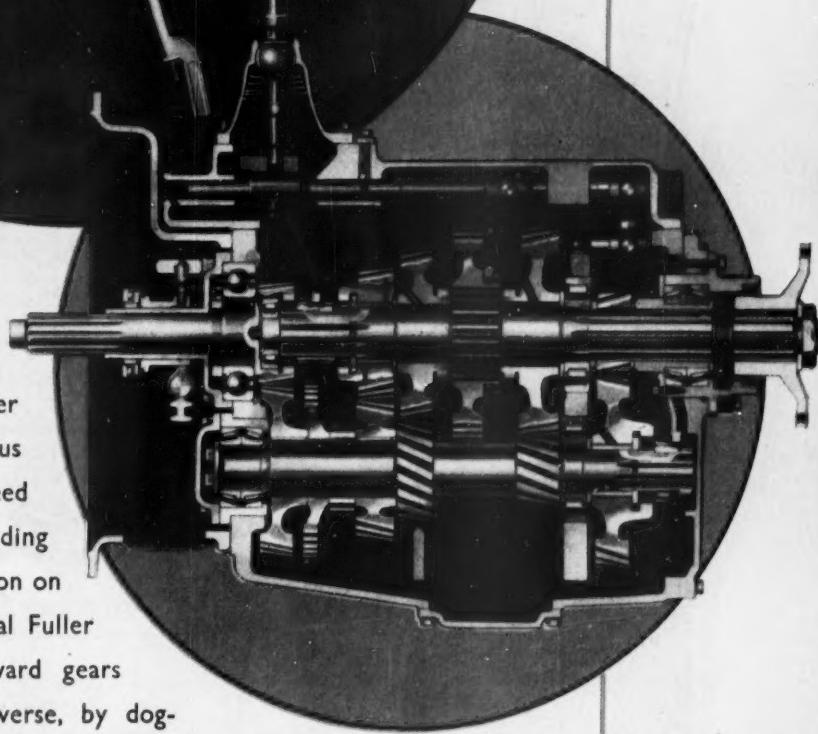




5 and 10-speed gear-boxes

The top illustration shows the Fuller 10-speed gear-box, comprising the famous five-speed box with a Fuller two-speed auxiliary box built on to it, thus providing a ten-speed box for heavy-duty operation on large trucks. This unit is to the usual Fuller standard of high-duty, with all forward gears helical, and all changes, including reverse, by dog-clutches. On both of these boxes the gears are shot-peened and crown-shaved, to avoid stress concentration.

The lower illustration shows the Fuller 5-speed gear-box. Every gear is helical and engaged by dog-clutches and to reduce shaft deflection to a minimum the mainshaft is supported on three bearings, and the layshaft kept short, making one of the highest-duty gear-boxes ever produced.

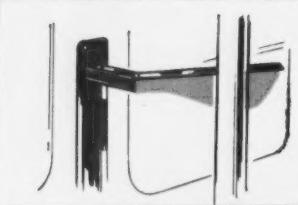


Exclusive European Representatives
AUTOMOTIVE PRODUCTS COMPANY LTD.
Brock House, Langham Street, London, W.1, England
Telephone: Langham 2527



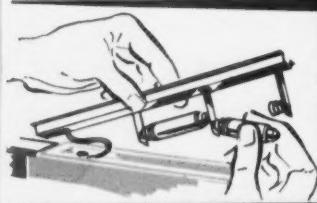
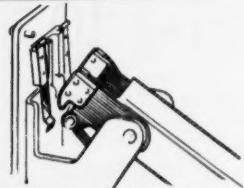


with the unique FLEXING ARM



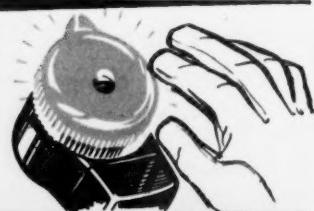
Spring controlled flexing arm prevents damage to mechanism if an obstacle is struck accidentally.

Hinge switch eliminates flexible leads to arm. Indicator lamps operate only in fully 'Up' position.



Twin bulbs in parallel as safeguard against failure, spring mounted to minimise shock. Bulb unit readily accessible.

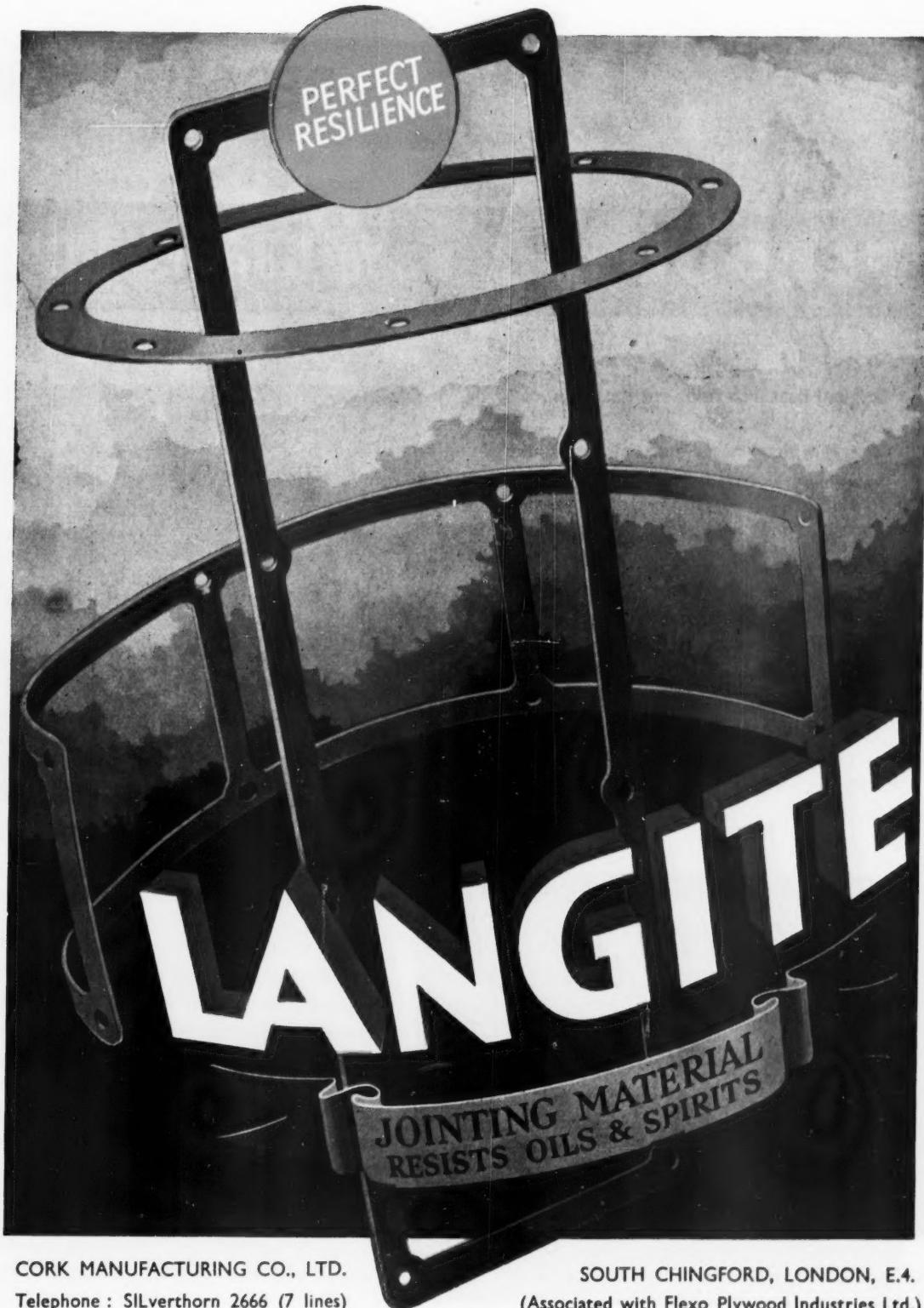
Delay switch cancels signal automatically after pre-set period (adjustable 5 to 20 secs.). Man-size switch for operation by gloved hands, with illuminated front, lit only when arm is fully raised.



Fuel Injection and Electrical Equipment

C. A. V. LIMITED, ACTON, LONDON, W. 3

© 174.465



CORK MANUFACTURING CO., LTD.
Telephone : SILverthorn 2666 (7 lines)

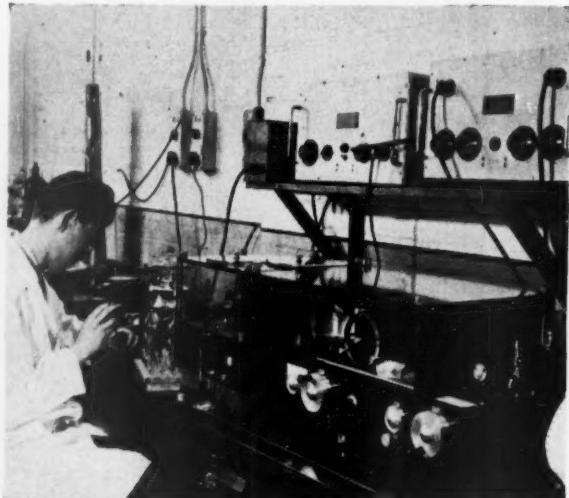
SOUTH CHINGFORD, LONDON, E.4.
(Associated with Flexo Plywood Industries Ltd.)

RESEARCH AND

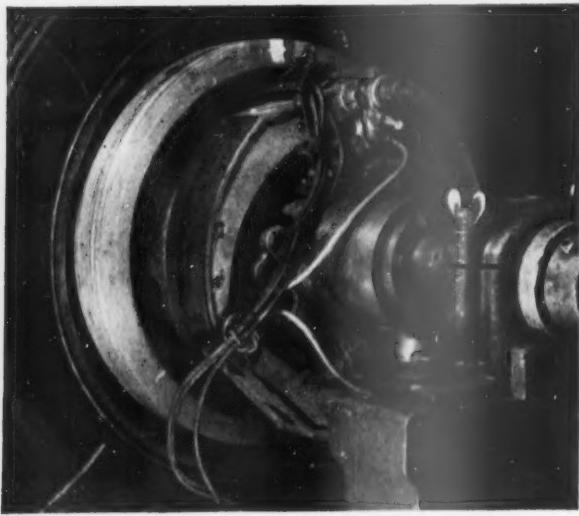
FERODO Anti-Fade BRAKE LININGS

Original Research finds out the facts

The choice of basic materials for brake lining manufacture depends on the fullest understanding of their properties. Often the facts are incomplete and, for this reason, Ferodo have undertaken original research into the fibre structure of asbestos, and the bonding and heat resisting properties of the resins which bond it to the other ingredients. On these and other subjects, such as interfacial phenomena and other variables which affect friction, the work of Ferodo's chemical research laboratory is not only increasing scientific knowledge generally, but ensuring the accurate composition of every type of Ferodo Lining.



Examination of raw materials by infra red spectroscopy.



Installation of a Lead Sulphide Cell Radiation Detector inside a Brake Assembly.

The Physical Test Laboratory checks Results

The Ferodo Physical Test Laboratory constitutes a completely new approach to brake lining evaluation. Ingenious machines, specially designed, subject sample linings to the equivalent of years of gruelling wear. This enables important tests to be made—under conditions far harsher than would ever actually be experienced—of friction, life, performance under high temperatures, and drum wear. (A lead sulphide cell radiation detector pyrometer tests brake linings for fade up to temperatures of 800°C.)

TESTING GIVES

EXTRA EFFICIENCY

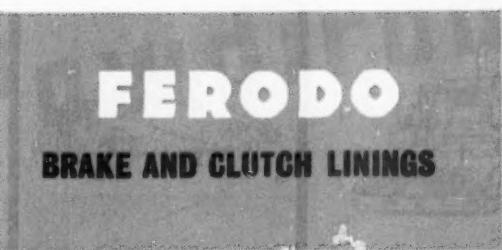


The Ferodo Test Car Fleet.

**The FERODO Car Fleet makes
conclusive tests**

Ferodo maintain a large fleet of cars for the final, practical testing of Ferodo Linings on the road and on the M.I.R.A. track. Sample linings are tested under every type of road condition and meticulous records made for checking with the results of laboratory tests.

Ferodo leave nothing to chance at any stage of brake lining manufacture. Their facilities for research and testing are the finest in the world. They are freely at the disposal of the motor industry at all times.



FERODO LIMITED · CHAPEL-EN-LE-FRITH
A Member of the Turner & Newall Organisation

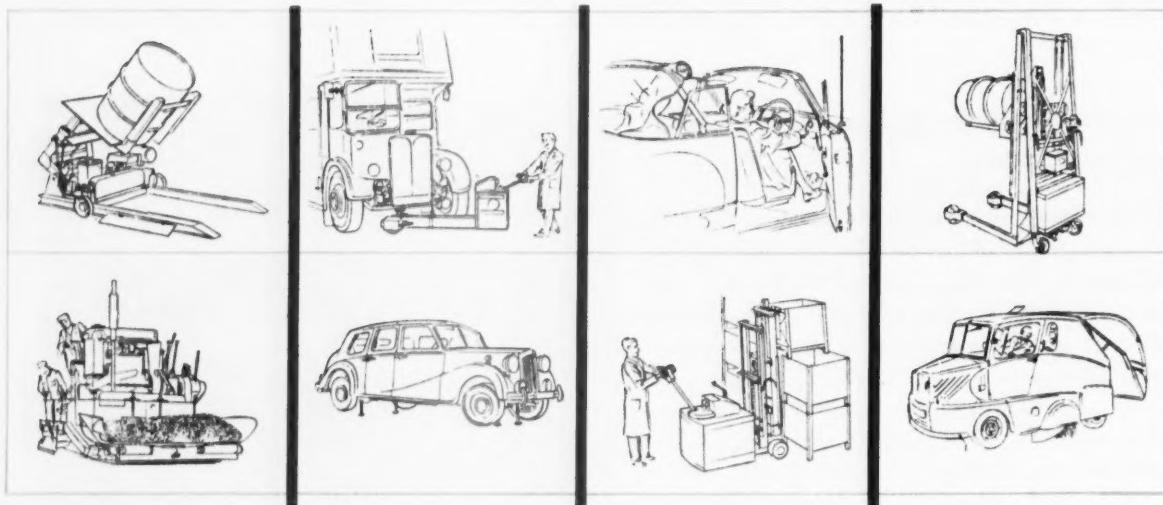
SMITHS

Hydraulics

take the load off your hands



S. J. S. hydraulics are used on mechanical handling plant, private, passenger and commercial vehicles, garage equipment, contractors' plant, agricultural machinery, and in many other varied applications.



SMITHS JACKING SYSTEMS LIMITED

A Company of the Motor Accessory Division of S. Smith & Sons (England) Ltd.

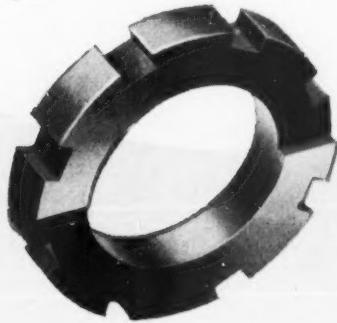
JACKALL WORKS, EDGWARE ROAD, LONDON, N.W.2

Telephone: GLADSTONE 6671-4
261-11



Machine and structural parts... without machining

Many of the smaller machine parts are expensive or difficult to make by conventional methods because of the machining involved. With the Powdiron process, metal powders are compressed into extremely accurate dies to produce intricate designs having such a smooth finish that further machining is eliminated. Naturally the shapes must be such that they can be produced in this way, but it is quite often possible to adjust a design so that it can be, without any loss of operational efficiency. We would like you to know more about the advantages of Powdiron. May we send you a copy of our folder "Sintered Components by Powder Metallurgy"?



Powdiron

SINTERED METAL PARTS

BOUND BROOK BEARINGS LTD., TRENT VALLEY TRADING ESTATE, LICHFIELD, STAFFS
Telephone: Lichfield 2027-2028 (A Birfield Company)

Telegrams: Boundless, Lichfield

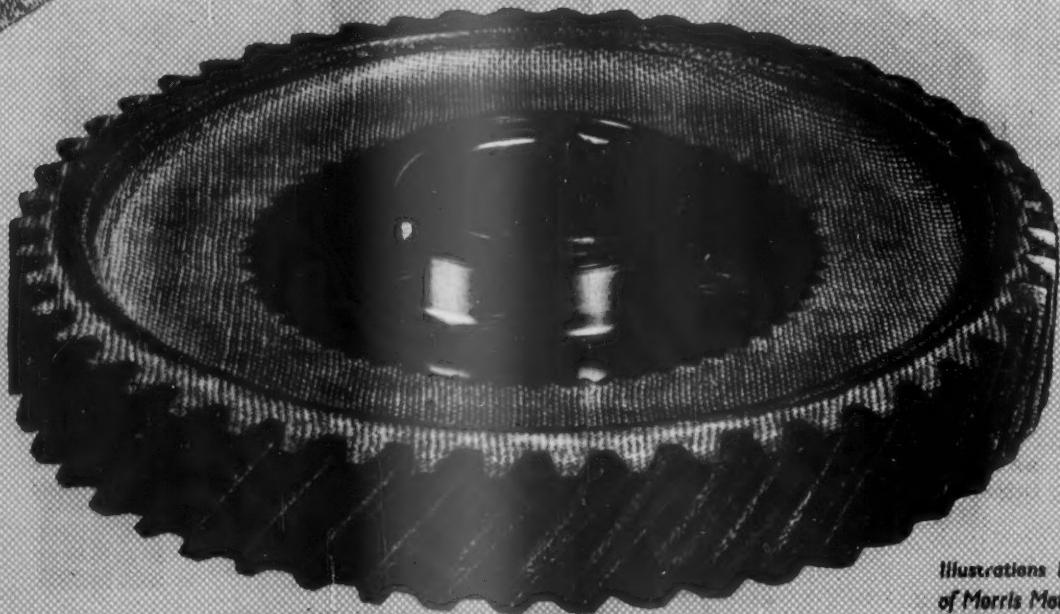
RE-INFORCED MOULDINGS

better in TEXOLEX

RE-INFORCED PLASTICS



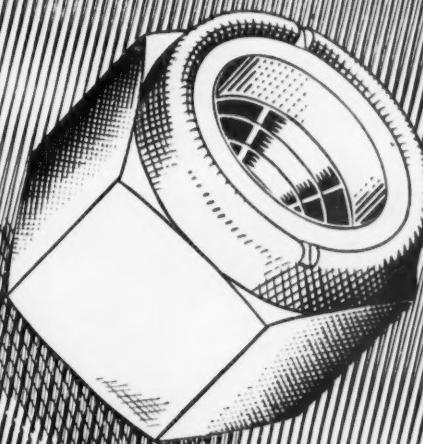
The illustrations show a sectioned gear blank and the finished spur gear



Illustrations by courtesy
of Morris Motors Limited

THE BUSHING CO. LTD., HEBBURN-ON-TYNE

nothing
rattles
the NYLOC



Sh-Sh-Shake

it how you will,

the great thing about

the Nyloc Nut is that, once it is screwed on, nothing can budge it except a spanner. Its special nylon insert locks so tightly on the bolt that you can vibrate it for hours on end and it still won't loosen. Heat it up to 200°C, freeze it to -65°C, soak it in oil or moisture — the Nyloc always stays put and it can be used over and over again.



The Fibre Nut with its fibre insert and the Pinnacle Nut with

its metal diaphragm are equally tenacious. If you have any problem that involves vibration, one of these three is the nut you are looking for. Let us advise you which is best for your particular job.



SIMMONDS SELF-LOCKING NUTS

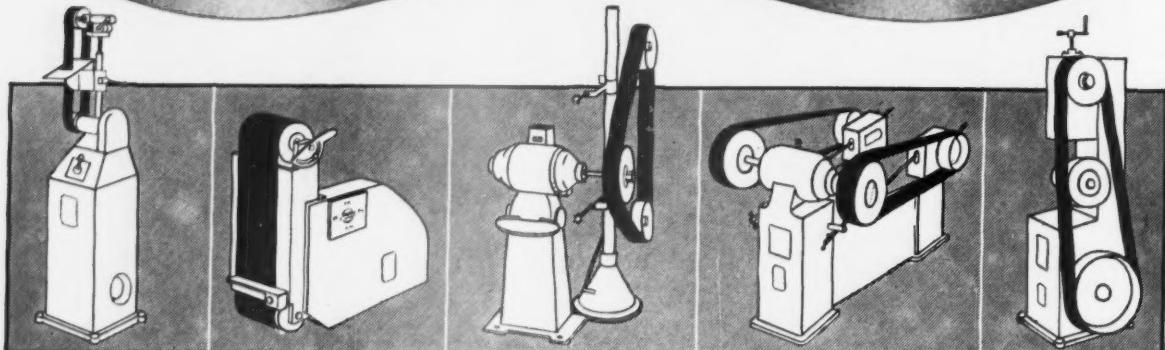
SIMMONDS AEROACCESSORIES LIMITED - TREFOREST - PONTYPRIDD - GLAMORGAN

Also Birmingham, Stockholm, Melbourne, Sydney, Amsterdam and Milan.

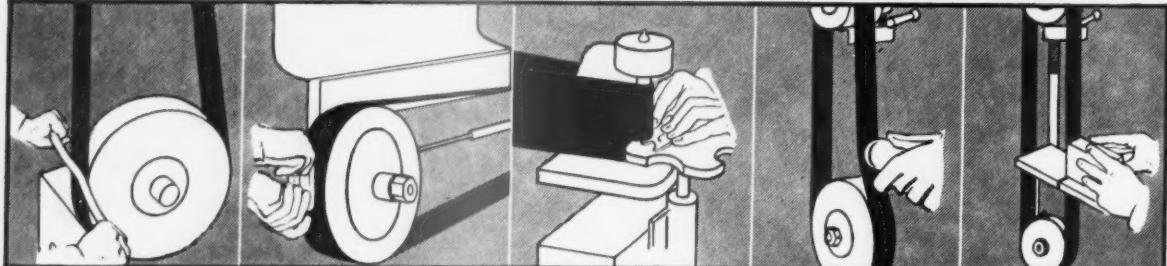
GRC BN

3M
COMPANY

ABRASIVE BANDS



FOR ALL KINDS OF BAND GRINDERS



A TYPE SUITABLE FOR EVERY APPLICATION

We stock a wide range of "3M" Abrasive Bands suitable for all types of band grinding machines. They are available in all the most generally used lengths and widths with skive and lap or interlined joints. Bands in standard grit numbers of "THREE-M-ITE" or "TRI-M-ITE" Abrasive Cloth can be supplied to cover all forms of grinding and polishing.

"3M" Abrasive Bands are flexible, long wearing and cool running at all speeds. For fast stock removal in roughing operations or the rapid generation of high-grade finishes on flat, curved or irregular shaped work, "3M" Abrasive Bands are at all times reliable and economical.

"TRI-M-ITE" has a grain of extreme hardness and sharpness. With its relative brittleness, as compared to "THREE-M-ITE", it is eminently suitable for the finishing of the softer metals.

"THREE-M-ITE" Cloth is coated with purified aluminium oxide grain, fused and crystallised; an abrasive of unequalled uniformity and hardness, it resists crushing strain and is suitable for cutting hard and tough metals.



DISTRIBUTORS:

BURTON GRIFFITHS & CO. LTD., MONTGOMERY ST., BIRMINGHAM 11.

'Phone:
Victoria 2351-9

BRISTOL, Mr. W. Barrington, 13, Briercliffe Road, Coombe Dingle.

Telephone: STOKE BISHOP 82333

CARDIFF, c/o Index Works, Cardiff.

Telephone: CARDIFF 24111

GLASGOW, 46, Carlton Place, C.S.

Telephone: SOUTH 1121/2

LEEDS, 27A, Butts Court, Albion Street, Leeds, 1. ...

Telephone: LEEDS 34251/2

LONDON, 93, Albert Embankment, S.E.11. Telephone: RELIANCE 3891/7

MANCHESTER, Daimler House, Wilmslow Road, 14. Telephone: RUSHOLME 2333/4

NEWCASTLE, Mr. C. H. Viles, 12, Holmwood Avenue, Monkseaton, Whitley Bay.

Telephone: Whitley Bay 24298

NOTTINGHAM, 51, Carrington Street. ...

Telephone: NOTTINGHAM 47701

M A D E B Y
The



TRADE MARK
MINNESOTA MINING &
MANUFACTURING CO. LTD
(Formerly Durex Abrasives Ltd)

OAKENSTRONG

Oil and Petrol GASKET MATERIALS



DISTRIBUTORS OF MATERIAL
IN BULK FOR GT. BRITAIN

J. A. NORDBERG LTD
171, QUEEN VICTORIA STREET
LONDON
E.C.4

FOREIGN & COLONIAL
ENQUIRIES TO

H. JACKSON LTD
OAKENCLOUGH, GARSTANG
nr. PRESTON
LANCS

OAKENCORK

**Syndromic
Automatic
Lubrication
soon pays
for itself!*



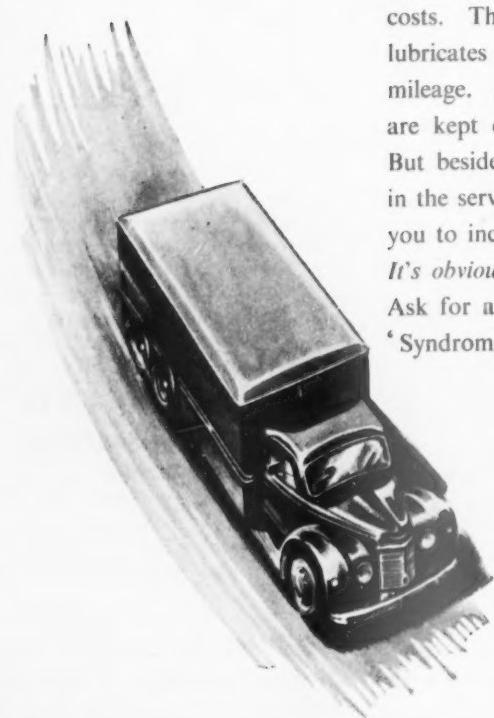
***INCREASES YOUR PAYLOADS 10%**

From the moment you equip your vehicle with 'Syndromic' Lubrication it begins to pay for itself ! First, it saves up to 75% on lubrication costs. Then, it ensures less wear on bearings because it automatically lubricates up to 80 bearings (using 2 pumps) at periods controlled by mileage. As a result, maintenance and replacement time and costs are kept down to a minimum.

But besides all that, 'Syndromic' lubrication saves the hours spent in the service bay. *It lubricates while the vehicle is working*, allowing you to increase your vehicles' payloads by as much as 10% !

It's obvious that 'Syndromic' lubrication soon pays for itself !

Ask for a Tecalemit technical representative to call and discuss the 'Syndromic' system with you.



TECALEMIT
The Authority on Lubrication

PLYMOUTH, ENGLAND

(AH) = HERBERT = (AH)



USE THE LUBRICAR...

Prolong Machine Life - Avoid Seizures - Reduce Repair Costs

A MOBILE UNIT WITH ALL THE EQUIPMENT AND LUBRICANTS FOR REGULAR OILING AND GREASING OF MACHINE TOOLS AND OTHER TYPES OF MACHINERY. PUMP AND FILTER FOR SALVAGING USED OIL FROM HEADSTOCKS AND GEARBOXES ALSO FITTED.

IN CHARGE OF A SUITABLY TRAINED OPERATOR, WORKING ON A REGULAR ROUTINE, THE LUBRICAR ENSURES EFFICIENT LUBRICATION. MOST MACHINES IN THE PLANT CAN BE COMPLETELY SERVICED AT REGULAR INTERVALS, PREVENTING BREAKDOWNS AND LOSS OF PRODUCTION. **OVER 400 SOLD.**

IMMEDIATE DELIVERY

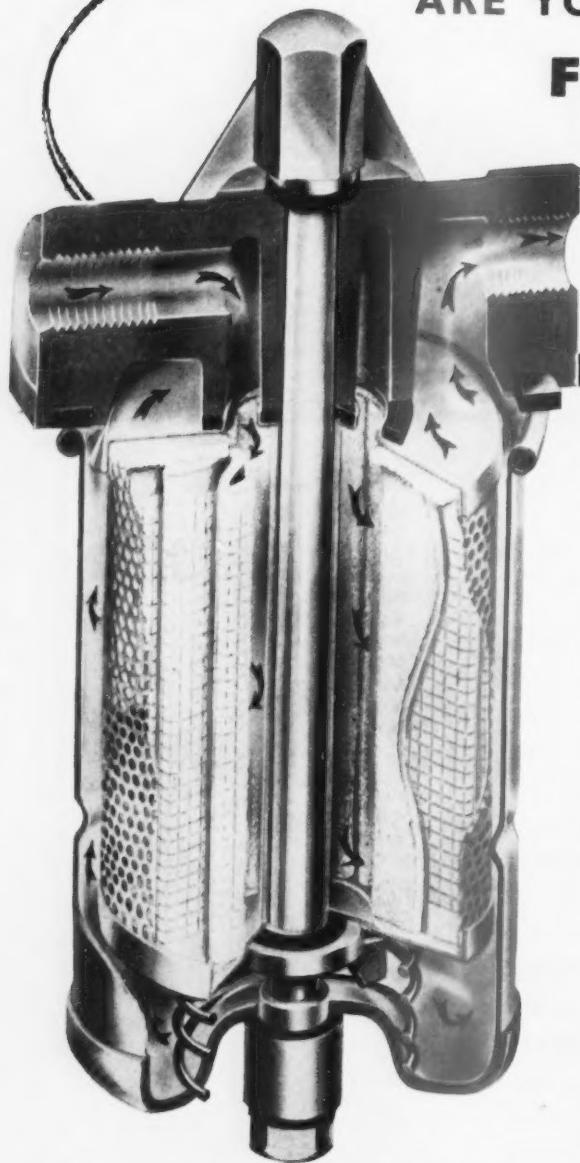
Full particulars from:-

FACTORED DIVISION, RED LANE WORKS. PHONE: 89221 (10 LINES)

SOME USERS

Austin Motors	..	..	..	..	8
W. & T. Avery	..	..	..	..	2
Accles & Pollock	..	..	..	..	2
Armstrong Siddeley Motors	..	..	..	..	2
Aveling & Barford	..	..	..	..	2
Bristol Aero	..	..	..	..	2
British Nylon	..	..	..	..	4
British Polar Engines	..	..	..	..	2
British Railways	..	..	..	..	5
Brockworth Engineering	..	..	..	..	2
C.A.V.	..	..	..	..	4
Consolidated Pneumatic	..	..	..	..	2
Dunlop Rim & Wheel	..	..	..	..	2
Dowty Equipment	..	..	..	..	2
Distington Engineering	..	..	..	..	2
Dobson & Barlow	..	..	..	..	2
English Steel Corporation	..	..	..	..	5
Firth Brown Tools	..	..	..	..	2
Ferranti	..	..	..	..	2
Humber	..	..	..	..	5
Harland & Wolff	..	..	..	..	2
International Harvester	..	..	..	..	2
Jowett Cars	..	..	..	..	2
Jaguar Cars	..	..	..	..	2
Lockheed	..	..	..	..	2
R. A. Lister	..	..	..	..	2
Jas. Lucas	..	..	..	..	11
Metro-Vickers	..	..	..	..	10
M.O.S.	..	..	..	..	10
Morris Motors	..	..	..	..	3
Napier	..	..	..	..	2
Pirelli	..	..	..	..	2
C. A. Parsons	..	..	..	..	4
F. Perkins	..	..	..	..	2
Rolls-Royce	..	..	..	..	16
Ruston & Hornsby	..	..	..	..	2
Rotax	..	..	..	..	3
R.O.F.	..	..	..	..	11
Rotary Hoes	..	..	..	..	2
Skefko	..	..	..	..	2
Standard Motors	..	..	..	..	2
J. E. Shay Ltd.	..	..	..	..	2
United Africa Co.	..	..	..	..	4
Vauxhall Motors	..	..	..	..	2
Vickers-Armstrongs	..	..	..	..	3
Anglo-Iranian Oil Co.	..	..	..	..	8
Australia	..	..	..	..	15
Brussels	..	..	..	..	3
Copenhagen	..	..	..	..	3
Oslo	..	..	..	..	2
India	..	..	..	..	11
Stockholm	..	..	..	..	18
Amsterdam	..	..	..	..	5
Netherlands Govt.	..	..	..	..	21
Paris	..	..	..	..	5
Zurich	..	..	..	..	14
Calcutta	..	..	..	..	2
Canada	..	..	..	..	6

ARE YOU GETTING
FILTRATION
IN
DEPTH ?



★ VOKES FABRIC ELEMENTS ARE
CLEANABLE !

They give greater economy in the long run and ensure that plant and machinery are not put out of service through the non-availability of spare elements in remote places.

VOKES

VOKES LIMITED · GUILDFORD · SURREY

VOKES (CANADA) LTD., Toronto.

Represented throughout the World.

VOKES AUSTRALIA PTY., LTD., Sydney



You must filter all the oil all the time—even a full flow filter is not doing its job if the by-pass is brought into use for long periods when the oil is only ordinarily cold. The VOKES direct flow device exists purely as a protection to the engine

and not to the filter. It only allows the oil to pass straight through to the engine if the filter has been so neglected that the element has been completely clogged up or if the oil is highly viscous through abnormal conditions.



Pioneers of scientific filtration

GEARBOXES for DIESEL CONVERSION UNITS



When converting your vehicle to Diesel, why not specify a David Brown Unit designed for this purpose?

MAXIMUM ENGINE TORQUE

Type	lb/in.	No. of speeds
45	3000	5
542	2210	5
437	1600	4
430C	1100	4

Large units also available.

THE
DAVID BROWN
CORPORATION (SALES) LIMITED
AUTOMOBILE GEARBOX DIVISION
PARK WORKS HUDDERSFIELD

Quality and Diversity in
**MILD STEEL FLAT
ROLLED PRODUCTS..**

MONTAIGNE wrote: '*The most universal quality is diversity*'

The craft of the steel producer rests in providing the diversity of products demanded by the customer, whilst maintaining and also enhancing his standards of quality.

RTSC Home Sales Limited sells in the home market the high quality Mild Steel Flat Rolled Products of RICHARD THOMAS & BALDWINS LIMITED and THE STEEL COMPANY OF WALES LIMITED comprising:—

Sheets (Uncoated and galvanised)	Welsh Charcoal Tinplate
Coils	Tinned Sheets
Plates (.1181" to .75")	Ternecoated Sheets
Tinplate	Leadcoated Sheets
Staffordshire Heavily Coated Tinplate	Terneplate
	Blackplate

Enquiries should be addressed to:—



RTSC Home Sales Limited
47 Park Street London W1

Telegraphic Address: "Homerald" Audley London · Telephone: Mayfair 8432

Provincial Offices in —

BIRMINGHAM · MANCHESTER · WOLVERHAMPTON





Trade Mark

TOOLROOM FAVOURITES

Illustration by courtesy of
Siemens Brothers & Co. Ltd.



970 This type of 2% Carbon 14% Chrome Steel is recommended for the highest duty work possessing the desired properties of deep hardening, a high resistance to abrasion together with the minimum amount of distortion in hardening. It also has the ability to withstand drawing in tempering after hardening over a much wider range of temperature than is normally permissible with standard alloy tool steel types. We also supply K. E. 961 1½% Carbon 14% Chrome Steel in cases where increased toughness is desired at the expense of a slight reduction in hardness.



595 A finely made type of Oil-Hardening Alloy Tool Steel, hard, durable and of excellent torsional properties in the hardened and tempered state and possessing low distortion values. Eminently suitable for Cut-Thread Taps, Reamers, Gauges, End Mills, Broaches, Press Tools etc.



672 The original universally known "Blue Line Die Steel". An excellent oil-hardening low distortion General Tool room quality.



637 A low temperature oil-hardening, non-shrinking quality possessing all those desirable features of a first grade tool steel.

All K.E. Tool Steels are supplied in the annealed condition, carefully controlled both with regard to temperature and atmosphere to render them most suitable for subsequent tool room manipulation.

KAYSER

ELLISON

& CO. LTD.

CARLISLE STEEL WORKS • SHEFFIELD • ESTABLISHED 1825
London Stock Warehouse:
4, Pembridge Mews, Notting Hill Gate, W.11. Tel: KEN. 9062/3



FLEXIBLE
COUPLING
COMPONENT



GEAR LEVER
COVER



FILTER
PLATE



REFRIGERATOR
LID



TELEVISION
MASKS



moulded
in
rubber



FLEXIBLE
LAMP HOLDER



MOULDED
RUBBER WHEELS

Rubber mouldings—often with metal

Insets—are all in the day's work at Andre's.

When desired we gladly co-operate in design
to make the best use of modern rubber tech-
niques. For intricate mouldings or those
required to meet exacting conditions,
it will pay you first to consult Andre.
Our technicians are at your service.

ANDRE RUBBER

Three Acres of Specialised Rubber Technology



ANDRE RUBBER COMPANY LTD. (A SILENTBLOC COMPANY)
KINGSTON CY-PASS, SURBITON, SURREY.
Telephone: HAMPTON 4580/3. Teleglobe: ANDRE, SURBITON.

looking for a fly in the ointment...



People in industry are getting particular. Whichever way you turn, you find them looking for the fly in the ointment, or seeking the nigger in the woodpile, or even looking gift horses in the mouth—peering not only *at* things but *into* them and *through* them. For this sort of poking and prying, those who are really up to date rely increasingly on radiography—aided and abetted, of course, by ILFORD Industrial X-ray films. The new ILFORD booklet "X-ray Films, Screens, and Chemicals for Industrial Radiography," is a treatise in miniature on this important branch of non-destructive testing. Write for a free copy today.

ILFORD

Industrial X-ray films

in the service of Industry

ILFORD LIMITED • ILFORD • LONDON



The 7 inch Heavy Duty Sander



Built for long life and hard work, the B & D Sander rubs down old paint, leaving the surface satin-smooth.

Fast, versatile, adaptable B & D Sanders cut time and costs on both production and maintenance work.



Built for many jobs

Here's a tool that's really versatile . . . it's built to sand, surface, de-rust . . . smooth down rough welds, rub down paint on wings or body panels prior to re-spraying . . . ideal for all body construction and general maintenance work. You must have many uses for this tough, dependable Sander, made by the world's largest manufacturers of portable electric tools for all industries. Other B & D tools include, Saws, Drills, Hammers, Screwdrivers, Bench & Portable Grinders,

Quicker and Better with

Black & Decker
PORTRABLE ELECTRIC TOOLS

Write for catalogue. Demonstration of any tool on request

BLACK & DECKER LTD • HARMONDSPORT • MIDDLESEX

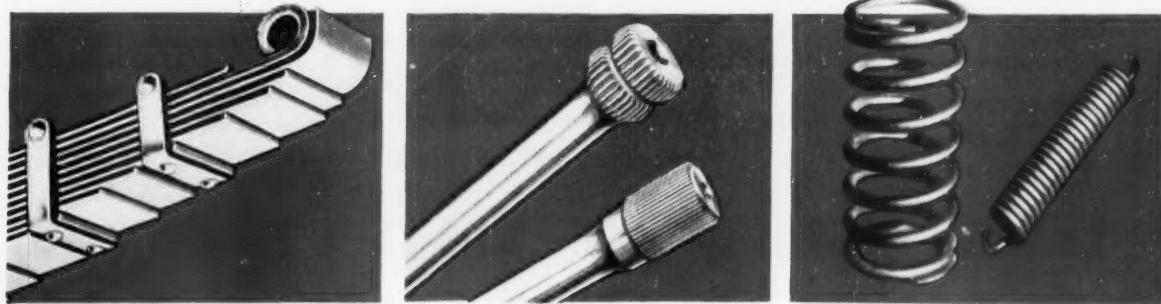
TOWSON, U.S.A. • TORONTO, CANADA • SYDNEY, AUSTRALIA • MEXICO D.F. SAO PAULO, BRASIL

Smee's 7/53



The man who's one jump ahead specifies

TOLEDO WOODHEAD SPRINGS



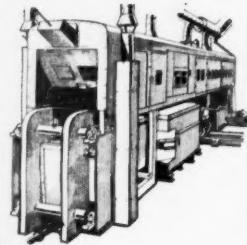
The first name that springs to mind!

TOLEDO WOODHEAD SPRINGS LIMITED SHEFFIELD 3

TWS.58



'CASSEL' HEAT TREATMENT SERVICE for the Cycle Industry



including

B.S.A., HERCULES, J. A. PHILLIPS

and **RALEIGH INDUSTRIES**

Salts and Salt Bath Furnaces for the casehardening of
pedal spindles, cups, cones, chainwheel sprockets
and three-speed gears and components.

- Accurate control of temperature
- Simplicity of operation • Low cost
- High output • Clean, scale-free finish
- Uniform results

DEMONSTRATION CENTRES

are maintained in Birmingham, London and Glasgow, where customers' problems are investigated and advice is given free of charge. Treatment of work is undertaken at normal commercial rates.

'CASSEL' HEAT TREATMENT SERVICE

IMPERIAL CHEMICAL INDUSTRIES LIMITED, LONDON, S.W.I



C.C.165

one foot on the ground!...

THE WIGGIN HIGH TEMPERATURE SERVICE

The selection of the best materials for use at high temperatures is a problem for the expert. That is where we can help. We have research data and service results covering the use of a wide range of materials in various operating conditions. Amongst this wealth of technical information we may already have the solution to your own high-temperature problem.

The chances are that one of our high-nickel alloys will best meet your requirements — but ask us *before* you go ahead.

Useful technical data on our high-temperature materials is contained in our publications. May we send you copies?

Wiggin High-Temperature Materials

INCONEL *
NIMONIC * 75
NIMONIC F
NIMONIC 80
NIMONIC 80A
NIMONIC 90
NIMONIC 95
NIMONIC DS

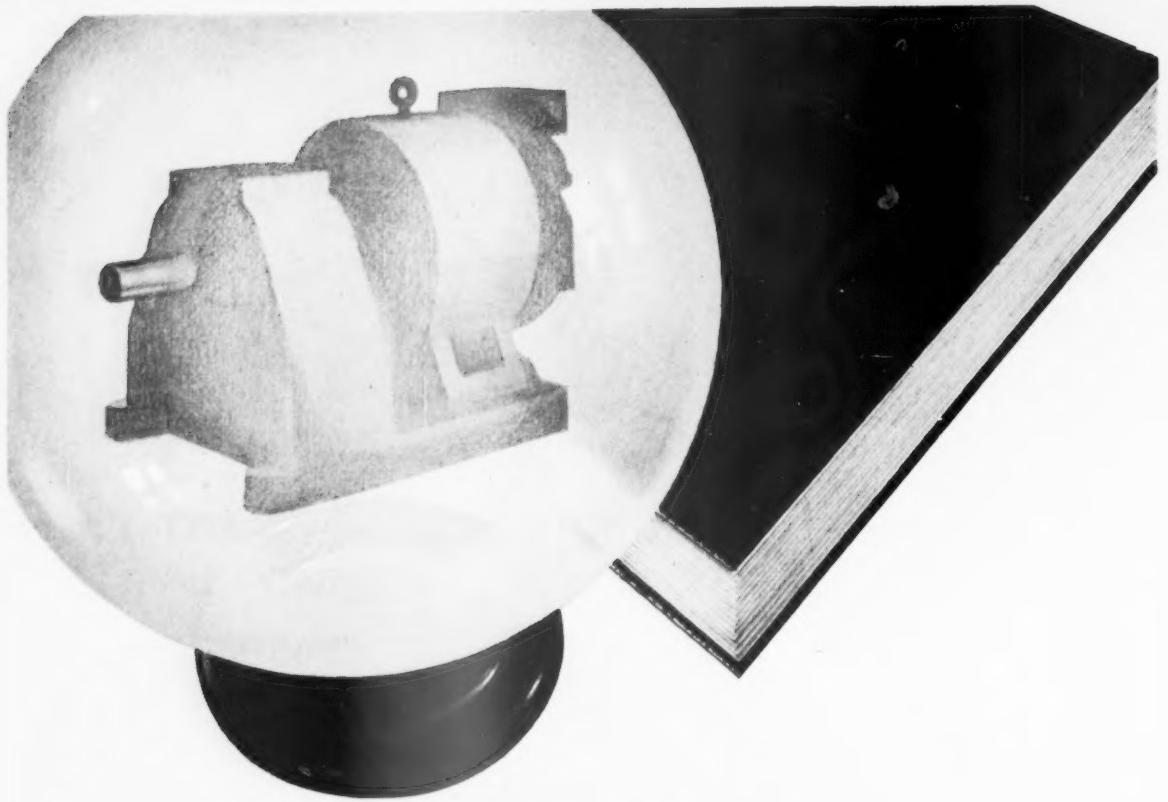
* Registered Trademark



FOR COLD FACTS ON HOT METALS



HENRY WIGGIN AND COMPANY LIMITED · WIGGIN STREET · BIRMINGHAM · 16



WHILE IT'S STILL IN THE FUTURE . . .

It is crystal clear that the most economical solution of bearing problems can best be achieved at an early stage of development. The design staffs of many famous firms are not too proud to call in Skefko, knowing that their very wide experience in bearing applications can pay dividends in simplification and consequent productivity in the machine shop and in erection. To say nothing of increased reliability and longer bearing life in the machine itself.

CONSULT . . .

SKF

THE SKEFKO BALL BEARING COMPANY LIMITED • LUTON • BEDS

THE ONLY BRITISH MANUFACTURER OF ALL FOUR BASIC BEARING TYPES:
BALL, CYLINDRICAL ROLLER, TAPER ROLLER AND SPHERICAL ROLLER

G.42

AUTOMOBILE ENGINEER

Design, Materials, Production Methods, and Works Equipment

Editor: J. B. DUNCAN

Editorial Staff: T. K. GARRETT, A.M.I.Mech.E., A.F.R.Ae.S., F. C. SHEFFIELD

Publishers: ILIFFE & SONS LTD., DORSET HOUSE, STAMFORD STREET, LONDON, S.E.1.
Telegrams: Sliderule, Sedist London

COVENTRY:
8-10, CORPORATION ST.
Telegrams: Autocar, Coventry
Telephone: Coventry 5210

BIRMINGHAM, 2:
KING EDWARD HOUSE, NEW ST.
Telegrams: Autopress, Birmingham
Telephone: MIDland 7191-7

MANCHESTER, 3:
260, DEANSGATE
Telegrams: Iliffe, Manchester
Telephone: Blackfriars 4412

GLASGOW, C.2:
268, RENFIELD ST.
Telegrams: Iliffe, Glasgow
Telephone: Central 1265-1266 (2 lines)

PUBLISHED MONTHLY—SECOND WEDNESDAY

Annual Subscription: Home and Overseas £2 11s. 6d., including the Special Number; Canada \$7.50; U.S.A. \$8.00

VOL. XLIII No. 574

DECEMBER, 1953

PRICE 3s. 6d.

Chassis Lubrication

MANUFACTURERS tend to be so engrossed with their immediate design and production problems that considerations relating to servicing operations to be performed by someone else at a later date are often not treated as methodically as they ought to be. This is particularly true of chassis lubrication. The situation at present is that not only are there on many models too many lubrication points, but also the recommended periods between lubrication operations vary enormously as between the products of different manufacturers. Moreover, a wide variety of lubricants sometimes is specified for use on each chassis.

At first sight, it would appear that standardization of recommendations to be made throughout the industry might be a fairly simple matter. However, this certainly is not so; nevertheless, much might be gained by co-operative study of the problem by the servicing trade, commercial vehicle operators, motor manufacturers and oil companies. Although, in this country, commercial vehicle operators and the trade generally would derive most benefit from any positive steps taken as a result of such a study, manufacturers would also find them to their advantage; for not only would simplification of lubrication requirements in itself gain for them much goodwill from their customers, but also servicing attention would tend to be better carried out and wear and tear would be reduced, so that further gains in goodwill would be made. Moreover, in some overseas markets, notably in the Americas, motor cars are expected to function for long periods with an absolute minimum of attention. Therefore, improvement in this direction would be a good selling point.

When laying down rules for servicing organizations, it is necessary, as in other matters, to consider carefully the human factor. At present the garage mechanic finds, for instance, that grease is specified for the lubrication of a certain component on one make of car, whereas for an identical part made by the same component manufacturer, but fitted in a different make of car, oil is specified. It is only natural, therefore, that he should be misled into believing that almost any lubricant will be satisfactory. As a result, he tends to use any grease or oil that he thinks fit and thereby limits his lubricant stock to a small variety. In any case, if he were to keep all of the wide range of lubricants recommended for the vehicles to be serviced, he might have no room left for other essential stores. The result of this is that servicing is often ineffective, and rapid

wear and failures result, to the detriment of the good name of the motor manufacturer.

The technical problem

Technically, it is impossible to specify one, two or even three oils or greases to cover the requirements of all lubrication points. Nevertheless, it might be possible to do more in the matter of classifying lubricants into grades recommended for specific applications. One standard list agreed upon by all concerned would tend both to change the present condition of chaos to one of order, and to raise the general standard of servicing.

Many difficulties arise when trying to restrict the varieties of lubricant to be specified for one chassis. For instance, whereas some manufacturers are satisfied that all the year round in this country only one grade of oil is needed for use in engine sumps, others specify a Winter and a Summer grade. Again, two grades are sometimes recommended for rear axles. Gearbox requirements fall between those of the engine and the axle, but frequently, to simplify maintenance, either sump oil is employed in the gearbox, or axle oil is specified. That there should be wide divergencies of opinion on this subject is not surprising because the properties essential for an engine oil are in some respects entirely opposed to those needed for a gearbox oil, and other objections apply to using axle lubricant in the gearbox.

Engine oil must retain a reasonable degree of viscosity at high temperatures; on the other hand, gear oil is required to operate at much lower temperatures and should not become too viscous when cold. Hypoid axles are now employed almost universally, and they require a special extreme-pressure lubricant. Unfortunately, some of the additives essential in oils for hypoid gears attack chemically the materials used for synchro-cones. Consequently, if a lubricant is to be specified as common to both the axle and the gearbox, some compromise is required. In fact, there seems to be at present a general trend towards the use of S.A.E. 80 oil for both axles and gearboxes. This is probably because lubricants of this viscosity are becoming more readily available; the S.A.E. 90 grade, hitherto widely employed in axles, tends to be too heavy for gearboxes.

Hand lubrication

So far as gun or hand lubrication is concerned, there are probably five fundamentally different types of application for lubricants, each with a different requirement. Rolling-

element type bearings call for a grease that will not channel and leave the balls or rollers dry. On the other hand, a high melting point grease is required in other bearings of the same type but which run at high speeds in components such as the wheels, where it is essential that grease shall not escape and get on the brake drums. Another application is to bush type bearings. These have to be lubricated by a grease or oil that will not easily squeeze out but which, when it does, will readily flow back between the surfaces at the unladen side, whence it may again be induced, by reversals of load or by rotation of the pin relative to the bush, to flow round to the other side. The fifth application is to items such as Bowden cables and other controls which cannot be sealed and, therefore, are liable to dry out. In these, graphite and grease is generally specified.

The problem of rationalization is further complicated by the fact that manufacturers of some of the components refuse to guarantee their products unless certain lubricants are employed. Nor can the marketing policies of the oil companies be ignored. Nevertheless, all, no doubt, could fall into line.

Decisions as to what periods between lubrication should be specified are always difficult because widely differing operating conditions must be catered for. There are two conflicting requirements: one is that the car owner or vehicle operator should not be asked to do more than is absolutely essential, and the other is that there shall be adequate safeguard against excessive wear arising from under-lubrication. Nevertheless, when, as is at present the case, one manufacturer specifies no lubrication attention for the first 1,000 miles, and another recommends greasing certain components including king pin bearings and steering rod joints every 250 miles, there is obviously something wrong. We believe that in this particular instance, attention definitely is needed every 250 miles, but the fact that this is so would appear to indicate that these points are over-loaded and that better design would have made it possible to call for less frequent lubrication.

This indicates that it is desirable to design specifically to reduce the amount of servicing required. To attain this end, it is necessary not only to provide adequate bearing areas, but also to arrange the geometry of the various assemblies in such a way that unduly heavy loads are not applied to the bearings. Moreover, much can be, and in many cases has been done to reduce the number of lubrication points.

About seven years ago, one British manufacturer con-

centrated on the elimination of as many lubrication points as practicable. The measures taken included the incorporation of an automatic chassis-lubrication system, the use where possible, of rubber bushes, sealed bearings, and reservoirs to ensure that a supply of lubricant to certain bearings was constantly available. Even when all possible had been done, there still remained about fourteen points requiring attention. Moreover, it has subsequently been found that sealed bearings and other devices for retaining the lubricant are not always satisfactory and, in many cases, their use has been abandoned. In fact, there has been a tendency to revert to hand lubricated bearings, for instance, in the water pump, instead of fitting sealed ones which are supposed to require no attention.

Although sweeping simplification may not be possible, at least some degree of rationalization ought to be practicable. Apart from compiling a standard list of lubricants for each component or group of similar components, standardization of periods between lubrication operations is desirable. Real benefits, for manufacturers, the trade and the customers, would accrue from the adoption of such a scheme.

Heaters

EVEN in our own temperate climate, heaters in which engine coolant is employed in the heat exchanger are hardly satisfactory for some time following a start from cold. Moreover they are relatively expensive and difficult to install. A better source of heat supply is the exhaust. Unfortunately, with jacketed exhaust pipes, there is a grave danger of leakage into the car body. For this reason, arrangements of this type are illegal in some countries.

However, it seems likely that the danger could be reduced at least to negligible proportions, if not eliminated altogether. One way of doing this would be to cast integrally with the heater jacket a central tube, and then to press the unit on to a straight portion of exhaust pipe, preferably adjacent to the manifold. In this way, should the exhaust pipe burn or corrode through, the gas would tend to blow out between the outer periphery of the pipe and the inner surface of the central tube of the jacket, thereby giving warning of the failure. Moreover, it is unlikely that the central tube would corrode through before the relatively thin exhaust pipe deteriorates to such an extent as to become completely unusable.

CONTENTS

Page	Page
Editorials	531-532
Chassis Lubrication. Heaters	531-532
Armstrong Siddeley Sapphire Engine	533-540
A 3·4 Litre Unit with an Exceptionally High Power:Weight Ratio	533-540
Low-Pressure Laminates. Richard Wood	541-549
Physical Properties: Design Considerations: Moulding Methods: Resin-impregnated Asbestos-fibre and Glass-fibre Materials	541-549
Carbo-Nitriding	550-552
A New Birlec Controlled-atmosphere Furnace for Light-case Work	550-552
Institution of Mechanical Engineers	552
Forthcoming Meetings of the Automobile Division	552
The Midland Red S.14	553-559
Advanced Features of Design Incorporated in a Single-decker Service Bus of Integral Construction	553-559
A Common Tolerance System. F. W. M. Lee	560-562
The "A.B.C. Proposals" Critically Examined	560-562
New Thrust Bearing	562
A Ball-type Bearing Designed for Clutch Withdrawal Mechanisms	562
Deep-Hole Boring. H. J. Pearson	563-570
Development of a New Production Process for High-speed Borings: Current German and Swedish Practice	563-570

ARMSTRONG SIDDELEY SAPPHIRE ENGINE

A 3·4 Litre Unit with an Exceptionally High Power:Weight Ratio

THE engine for the Armstrong Siddeley Sapphire was, of course, designed specifically to conform with the general policy laid down for the chassis design. This policy was to aim at a high top speed and good acceleration, not with a view to making a sports car of the vehicle, but rather to permit high cruising speeds to be comfortably and economically maintained without overstressing the power unit. Since the car is capable of a relatively high speed, it follows that when cruising at 60-65 m.p.h. the engine speed is moderate, so the rate of wear of the cylinders, bearings, and other components is low, as also is the fuel consumption expressed in terms of pt/b.h.p.-hr.

To meet the design requirements specified above, a high power:weight ratio was essential and, since the car was to be marketed at a highly competitive price, this performance had to be obtained without resorting to expensive arrangements. The twin overhead camshaft layout, because of the light weight of the reciprocating components, as well as for other reasons, is undoubtedly the best for the very high speeds required of power units for sports cars. By restricting the maximum engine r.p.m. to a more reasonable figure, however, it is possible to obtain equally good torque characteristics with push rod and rocker operated valves. The push rod and low camshaft system was adopted because it is relatively inexpensive, a short and simple chain drive can be used and only one camshaft is needed.

During the development stage, a

SPECIFICATION

ENGINE: Six cylinders. Bore and stroke 90 mm by 90 mm. Swept volume 3,435 cm³. Firing order: 1, 5, 3, 6, 2, 4. Maximum b.h.p. 150 at 5,000 r.p.m. with twin carburettors and 125 b.h.p. at 4,700 r.p.m. with one carburettor. Maximum b.m.e.p. and torque respectively 140 lb/in² and 198 lb-ft at 2,000 r.p.m. with twin carburettors, and 131 lb/in² and 182 lb-ft at 2,000 r.p.m. with one carburettor. Compression ratio: 7:1. Fully balanced, four-bearing, forged crankshaft. Overhead valves, push rod operated. Carburettors: twin DAA36 Stromberg units; or single DAV36 Stromberg unit, each with a choke diameter of 1½ in. Hemispherical combustion chambers. A.C. mechanical fuel lift pump.

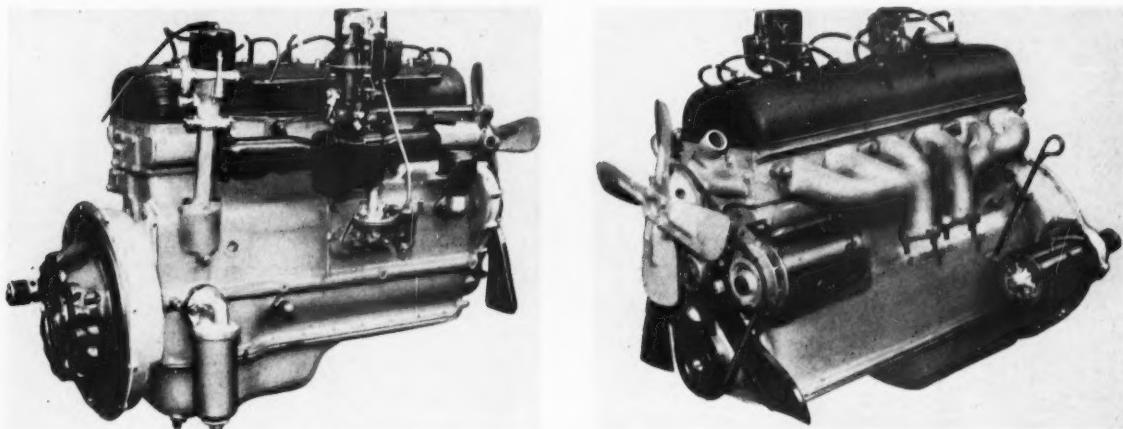
squish-type of combustion chamber, with in-line valves, was first specified mainly because it was thought that smoother running characteristics might be obtained as a result of the turbulence induced by this arrangement. However, it was decided also to try a hemispherical combustion chamber design, and this was found to give equally good results, so far as smoothness was concerned. Moreover, the greater power output obtainable with this layout was deemed fully to justify the extra cost arising from the necessity for employing two rocker shafts, one for the inlet and the other for the exhaust valves.

Although the weight of the unit had to be kept as low as possible, cast iron was specified for the main components

such as the crankcase and cylinder head. Had aluminium been employed, the cost would have been much higher. Another feature that has led to economy of weight is the square bore:stroke ratio. This has reduced the overall height of the engine, although it may have slightly increased the length. It has also led to a greater volumetric efficiency by making possible the incorporation of bigger valve ports. Because of the large diameter cylinder bores there is ample room for the main journal bearings.

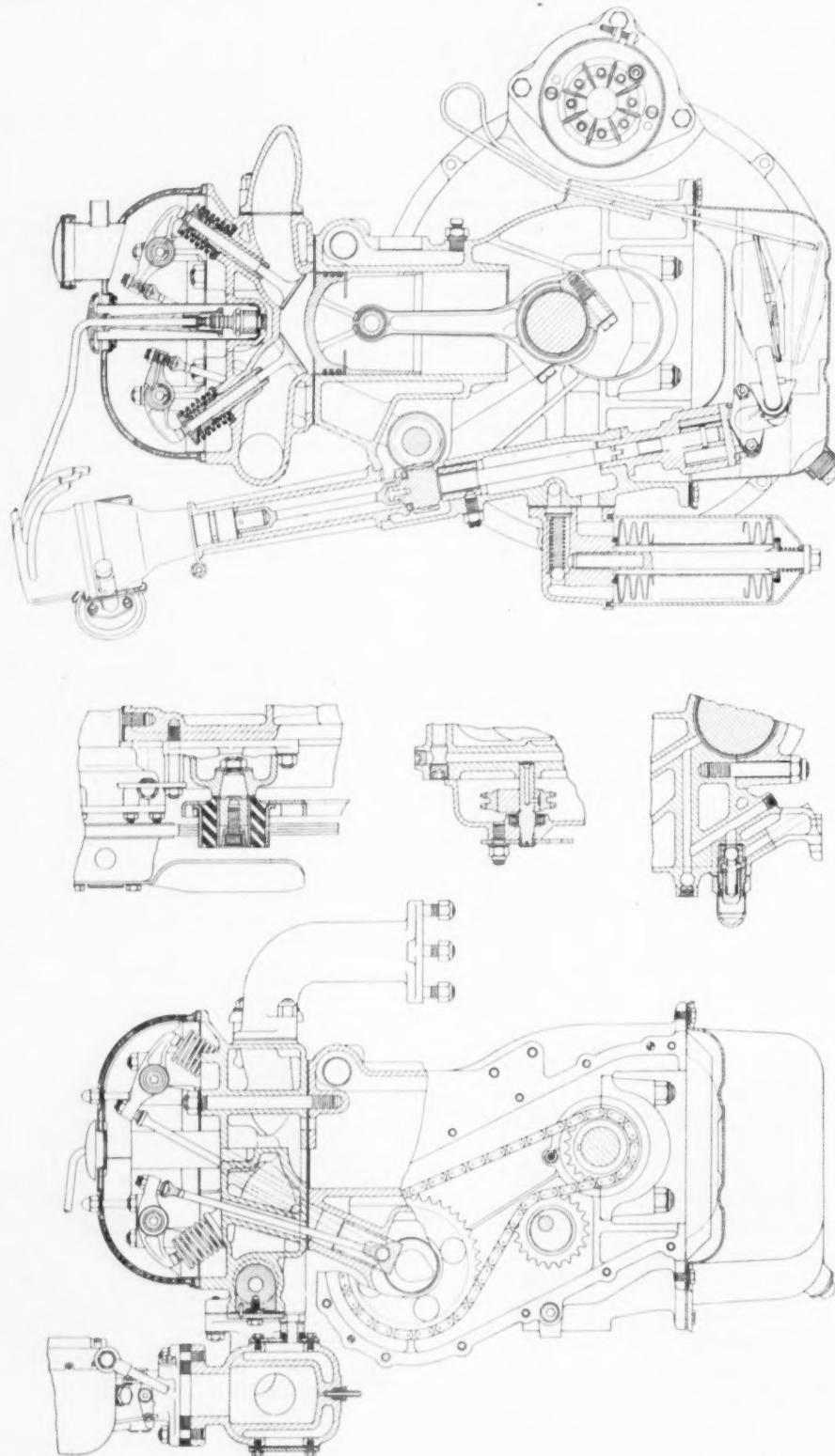
The general arrangement of the main components is as follows: An integral cylinder block and crankcase casting carries the four-bearing crankshaft. On its right-hand side is the camshaft, which is positioned at a level approximately midway between the top and bottom of the cylinders. This height represents a compromise between conflicting requirements; on the one hand it had to be as high as possible in order that the push rods may be of minimum weight, while on the other hand, it could not be placed in too high a position otherwise the rods would have been inclined at too great an angle, relative to the rocker arms, for efficient operation.

One large rocker cover encloses the valve gear. The two rocker shafts are carried on pedestals mounted on raised bosses on the cylinder head. These bosses are incorporated so that the face on which the pedestals seat and the joint face for the rocker cover may be machined in one operation. The induction manifolds are on the right and the exhaust manifolds are on the left.



The single carburettor installation on the right-hand side of the power unit for the Armstrong Siddeley Sapphire

A high-point type of mounting is carried on a bridge piece at the front of this engine



CROSS SECTIONS OF THE ARMSTRONG SIDDELEY SAPPHIRE ENGINE
The scrap views show the arrangements of the front mounting, jockey sprocket for the timing chain, and oil relief valve

A conventional triangulated V-belt arrangement is employed to drive the dynamo, and fan and water pump. The pump is bolted to the cylinder head, and the generator is pivot mounted on the left-hand side of the crankcase. Also on this side is the starter motor, which is bolted to a flange on the flywheel casing. On the right-hand side is the contact breaker and distributor unit, breather, oil filter and the mechanically operated fuel pump, which is actuated by an eccentric on the camshaft.

A bore:stroke ratio of 1:1 has been adopted, and the connecting rod length:stroke ratio is 1.834:1. When a single carburettor is employed, the mean piston speed at maximum b.h.p. is 2,776 ft/min at 4,700 r.p.m. The maximum b.m.e.p. is 131 lb/in² at 2,000 r.p.m., and the i.m.e.p. at the same speed is 152 lb/in². This gives a mechanical efficiency of 86.25 per cent. The power output is 2.11 b.h.p./in² piston area, and in terms of b.h.p./litre it is 36.4. Without the clutch and gearbox the engine weighs 574 lb dry, so the b.h.p. developed per pound is 0.218. This is an exceptionally good performance for an automobile engine. The minimum brake specific fuel consumption is 0.51 pt/b.h.p.-hr.

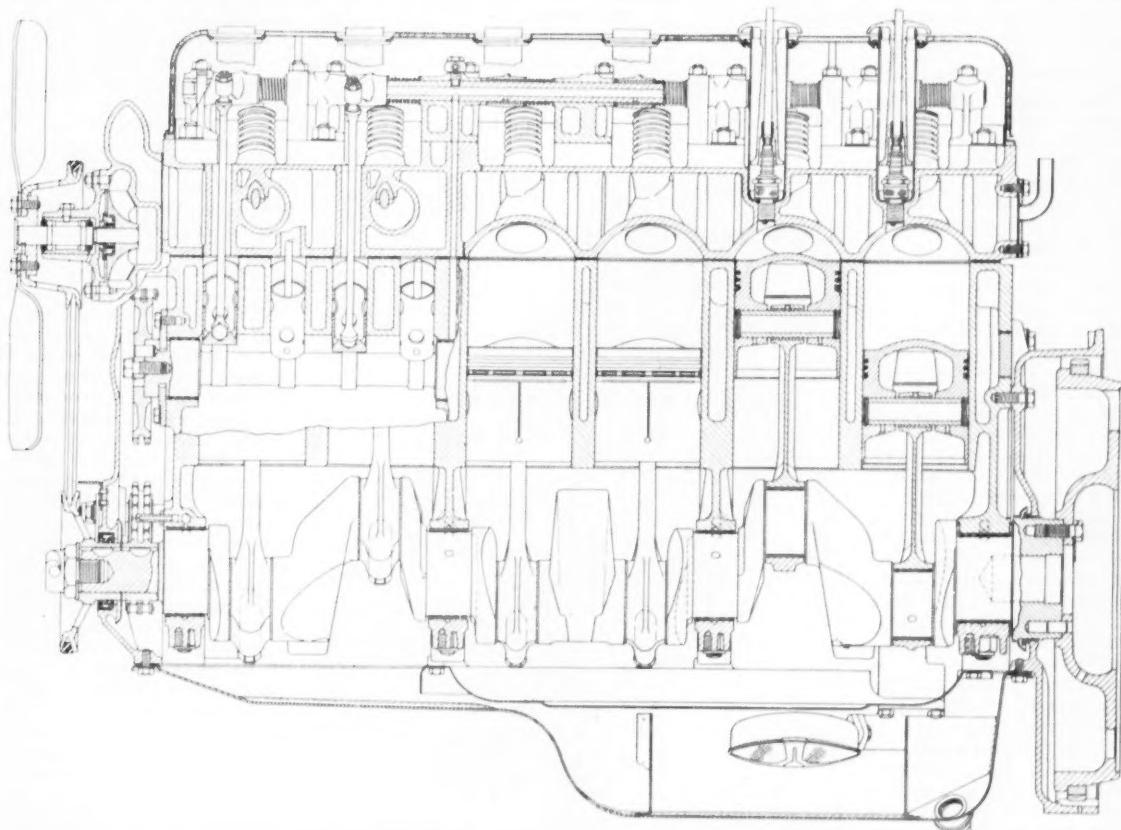
With two carburettors, the mean piston speed at maximum b.h.p. is 2,953 ft/min at 5,000 r.p.m. The maxi-

mum b.m.e.p. is 140 lb/in² at 2,000 r.p.m. while at the same speed, the i.m.e.p. is 160 lb/in². This gives a mechanical efficiency of 87.6 per cent. The power output is 2.54 b.h.p./in² piston area, and the b.h.p./litre is 43.6. Although the additional carburettor will add to the engine weight, the power output per pound should be appreciably better than that quoted for the single carburettor engine. The minimum brake specific fuel consumption is 0.515 pt/b.h.p.-hr. The overall height of the unit, less air filter, is 30½ in, its width is 22 in and the overall length, less flywheel, is 37 in. An engine installation angle of 1 deg 15 min relative to the horizontal plane of the frame has been adopted.

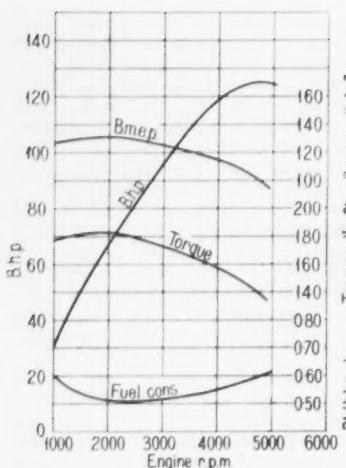
Metalastik engine-mounting units are employed. At the front, a single high-point layout has been adopted, a Metaxentric rubber-bush type unit being carried on a pressed steel bridge piece, approximately $\frac{1}{8}$ in thick, which is bolted to the frame side members. The axis of this bush is approximately coincident with the axis of oscillation of the power unit. The inner metal tube is carried on a trunnion pin, on one end of which is a taper and a $\frac{1}{2}$ in diameter threaded extension for the nut which pulls it into a tapered hole in a small malleable iron casting bolted to the front wall of the cylinder block.

Accurate axial location of this front mounting is, of course, impracticable so, during assembly, the engine is lowered first on to its rear mountings and then the pressed steel bridge piece at the front is bolted to the frame. Then the inner tube of the Metaxentric bush unit is locked in position by means of an Allen socket-screw, in an axial hole in the trunnion pin, and a male and female split-cone arrangement. The socket-screw is countersunk into the inner cone to restrict the overall length of the mounting unit. This is necessary because it has to be accommodated in the space available between the fan and the cylinder block. It is the outer, or female, cone that is split, and the inner one is pulled into it until it expands and firmly grips the bore of the inner tube of the mounting unit. A small dowel in the split cone and the front end of the trunnion pin prevents relative movement taking place between them, which, during service, might cause the socket screw to work loose.

Although this single high-point type of front mounting is difficult to accommodate and calls for positive fore-and-aft location at the rear mountings, it has the advantage that it completely isolates the vehicle structure from the large amplitude rocking vibrations of the engine when running at tick-over speed. The more conventional V-type



Longitudinal section of the Armstrong Siddeley Sapphire engine.
Bore and stroke 90 mm × 90 mm. Swept volume 3,435 cm³.



Performance curves for the engine when fitted with a single carburettor

layout does not do this entirely satisfactorily, because of the relatively large distance of the rubber units from the axis of oscillation. At the rear, the two Metacone units, one on each side of the gearbox rear extension, are bolted to brackets on a frame cross member. A pressed steel yoke over the top of the gearbox extension is bolted to the centre tubes of these cone mountings, which provide the necessary fore-and-aft location while allowing it to oscillate relatively freely.

Cylinder block and crankcase

The integral cylinder block and crankcase unit is of B.S. 1452 grade 14 cast iron. A finish of 25μ in has been adopted for the cylinder bores, and the thickness of the walls is 0.23 in. The minimum space between the cylinders is 0.3 in, and the jackets extend up to the level of the top ring when the piston is at top dead centre. This is a good feature and should give adequate cooling at the upper ends of the bores where it is most needed. The skirt of the cylinder extends approximately $1\frac{1}{2}$ in below the jackets, but the cooling of this end presents no problems since at no time during the stroke is it exposed to the combustion gases. Cylinder wall distortion, arising from the loads applied by the cylinder head holding down studs, has been reduced to an absolute minimum by positioning the bosses for the studs symmetrically about the cylinder walls, and as far as possible away from them.

At the rear, a separate, cast aluminium alloy, flywheel housing is bolted-on and located by two $\frac{1}{2}$ in diameter silver steel dowels. No joint washer is fitted. A machined face near the bottom of this

casting forms part of the sump joint face, which is 3 in below the axis of the main journals, and also forms the oil seal behind the rear bearing cap. The front cover is also a bolted-on aluminium alloy casting, and its lower face is machined to form the joint face for the sump which seals in front of the adjacent bearing cap in a manner similar to that just described for the rear. An Oakenstrong joint washer is employed between the timing cover and the crankcase, while a Corok sump joint washer is employed.

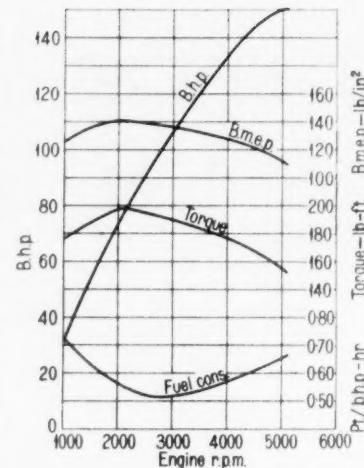
Two transverse webs and the end walls of the crankcase carry the four main journal bearings, as well as the four camshaft bearings the axes of which are at a level approximately $6\frac{1}{2}$ in above the axis of the crankshaft. The crankcase webs and end walls are stiffened by ribs extending radially from the bearing housings to a point on each side, at the junction between the crankcase side walls and the cylinder block. Two $\frac{1}{2}$ in diameter B.S.F. studs, of En 100T, and Simmonds Pinnacle self-locking nuts, hold down each bearing cap. These caps are laterally located between $\frac{1}{2}$ in high shoulders on each side of their seats on the housings. To facilitate their withdrawal for servicing, a hole for an extractor bolt is drilled and tapped in a boss below the centre of each cap.

Crankshaft, connecting rods and pistons

An En 9T crankshaft is employed, and it is balanced in the usual manner by weights cast integrally with the crank webs adjacent to the two end main journal bearings and by another



A deep-skirted crankcase is employed



Performance curves for the engine when fitted with two carburettors

balance weight midway between Nos. 3 and 4 crank pins. Semi-circular washers are fitted in grooves in front of and behind the rear journal housing to take the thrust. Each of the four main journals are 2.7505-2.7510 in diameter. Vandervell D2 bi-metal, babbitt-lined, shells are fitted and they are located in the conventional way by means of pressed-out tabs at the abutting faces of each half-shell. The effective bearing lengths are as follows: front and intermediate 1.245-1.255 in, rear 1.620-1.630 in. In all the main journal bearings the diametral clearance is 0.001-0.0025 in.

From the front of the front web to the back of the rear web, the length of the crankshaft is 24.9 in; the web thickness is 0.65 in, while the thickness of the inclined crank arms is $1\frac{1}{2}$ in. The diameter of the crank pins is 2.1250-2.1255 in. An oil-return scroll is cut round the rear of the shaft and works in a machined bore in a boss in the flywheel housing. The outer periphery of the inner end of this boss is lipped, and shrouded by a dished thrower ring pressed on a collar round the shaft. When a synchromesh gearbox is fitted, a Hoffmann 120 FS bearing is carried in the tail end of the shaft and supports the primary shaft. On the other hand, when the pre-selector gearbox is fitted, the end of the primary shaft is not supported in the tail end of the crankshaft, but is overhung from a Hoffmann LS11 bearing in a housing bolted to the front of the gearbox. This layout has been adopted because it has been found to lead to smoother operation of the centrifugal clutch than is possible with the more conventional arrangement.

A relatively light, 18-ton

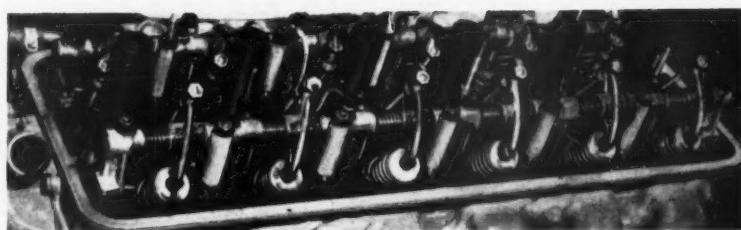
cast iron, flywheel is spigoted and bolted on the tail end of the crankshaft, and it is located by two $\frac{1}{8}$ in diameter silver-steel dowels. The overall diameter of the flywheel used with the synchromesh box is 14.336 in, the rim is 1.5 in wide by 1.56 in, and the unit weighs 41 lb. When the pre-selector gearbox is employed, the flywheel is of En 8 and it weighs 28 $\frac{1}{2}$ lb. Its diameter is the same but the rim is 2.2 in wide by 0.44 in. In both cases an En 8A starter ring gear with 142 teeth is shrunk on. This gear is heat-treated to a Brinell hardness figure of 255-277.

I-section connecting rods of En 8Q, with a centre-to-centre length of 6.499-6.501 in, are employed. The I-section tapers between the big- and small-ends from 0.90-0.80 in deep, the web thickness is 0.090-0.120 and the width over the flanges is 0.51-0.55 in. The weight distribution of the rod, complete with bearings, set bolts and tab washers, is estimated to be 1.4521 lb on the big end and 0.3789 lb on the small end.

The big ends are split at an angle of 40 deg from the axis of the rod and location is effected by dowel tubes round the $\frac{1}{8}$ in diameter, B.S.F., En 16U set bolts that secure the caps. These bolts are locked by tab washers. In the big ends, Vandervell D2 bi-metal, babbitt-lined shells are fitted. The length of the bearings is 1.120-1.130 in and the diametral clearance is 0.001-0.0025 in. A Vandervell Clevite B305 bush is pressed into the small end. It is 1.08 in long and the diametral clearance between the gudgeon pin and the bush is from 0-0.0004 in.

A high tensile steel, 2S14 gudgeon pin with a Rockwell hardness figure of C57-C63 is fitted. Its inside diameter is 0.625 in while the outside diameter is 0.8750-0.8752 in. In each of the piston bosses, the gudgeon pin bearing length is 0.89 in, and the diametral clearance, when cold is from +0.0001 in to -0.0003 in, that is, an interference fit. This ensures that, under sparsely lubricated conditions obtaining when starting from cold, relative motion takes place between the bush and the pin rather than between the pin and the piston boss. Axial location is effected by circlips in the bosses.

Brico slotted-skirt pistons of low-expansion aluminium alloy are employed. Each piston carries two compression rings and one oil control ring. The top compression ring is chromium plated while the second one is taper-faced and oxidized, and its top face is stamped with a T for identification. The dimensions of the compression rings are as follows: free gap, 0.49 in;



Inclined push rods actuate the rockers, which are carried on two shafts

when in the bore, the gap is 0.010-0.015 in; face width 0.0928-0.0938 in; radial thickness 0.136-0.143 in; depth of groove in piston 0.153-0.157 in; side clearance 0.0015-0.0035 in. The dimensions of the Maxigroove, oxidized oil control ring are the same as those of the compression rings, except in that the face width is 0.1553-0.1563 in. The complete assembly including rings, gudgeon pin and circlip weighs 1.50 lb.

VALVE DATA

	Inlet	Exhaust
Material	Silchrome	Silchrome XB
Head diameter	1.695-1.700 in	1.485-1.490 in
Throat diameter	1.45 in	1.345-1.350 in
Stem diameter	0.340-0.341 in	
Diametrical clearance	0.0005-0.002 in	0.0012-0.0027 in
Seat angle	45 deg	
Valve seat material	Cut in cylinder head	
Spring material	DTD 5A	
Spring rate,		
inner	46.75 lb/in	
outer	75 lb/in	
Spring length, free,		
inner	2.10 in	
outer	2.44 in	
Spring length, installed,		
inner	1.437 in	
outer	1.566 in	
Number of coils, effective,		
inner	7½	
outer	5½	
Coil diameter, mean,		
inner	0.782 in	
outer	1.144 in	
Wire gauge,		
inner	12 S.W.G.	
outer	9 S.W.G.	
Valve lift	0.3588 in	0.3075 in
Rocker ratio	-1.28 : 1	1.30 : 1
Valve crash speed		5,200 r.p.m.
Valve guide material		B.S. 1452 Grade 14
Valve guide length		2.40 in
Inside diameter	0.3415-0.3420 in	0.3422-0.3427 in
Outside diameter	0.6260-0.6265 in	0.6260-0.6265 in
Tappet clearance, hot,		0.006 in
Tappet clearance, cold for timing only	0.016 in	0.014 in
Valve opens	8 deg B.T.D.C.	46 deg B.B.D.C.
Valve closes	62 deg A.B.D.C.	18 deg A.T.D.C.
Ignition timing	7 deg B.T.D.C.	

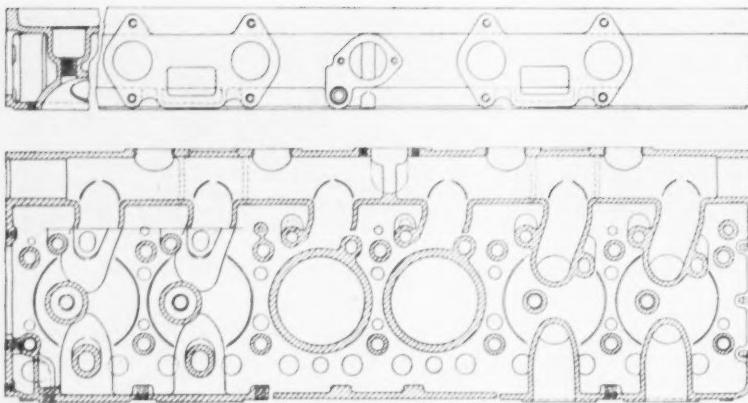
Timing gear, camshaft and valve gear

Two Woodruff keys in the 1.3742-1.3747 in diameter front extension of the crankshaft furnish the drive for the cast iron fan belt pulley and En 9T timing gear drive-sprocket, which are held on by an En 9T special bolt. This bolt is screwed into the $\frac{1}{4}$ in diameter B.S.F. tapped hole in the end of the crankshaft extension, and on its head are incorporated the dogs for the

starter handle. A Super oil seal is carried in the timing cover and bears on the boss of the pulley. The outer periphery of the rear end of the housing for this seal is lipped and partly shrouded by a pressed steel thrower ring which is clamped between the bosses of the pulley and timing drive sprocket. With this arrangement, oil can neither be splashed directly on to the seal nor can it run down from the outer periphery of its housing on to the seal.

A $\frac{1}{8}$ in pitch, two strand Reynolds chain transmits the drive to the B.S. 1452 grade 14, cast iron half speed wheel, which is secured by a single En 16U, $\frac{1}{8}$ in diameter, B.S.F. bolt screwed axially into the end of the camshaft. This wheel is positively located by a $\frac{1}{8}$ in diameter dowel. Chain tension is maintained by an eccentric jockey sprocket. Adjustment may be made without removing the timing cover and it is effected in a somewhat unconventional manner. The eccentric is splined on to its spindle, the rear end of which is carried in a boss on the front wall of the crankcase, while its front end extends through a hole in the timing cover in which is housed a rubber seal round the spindle. A quadrant plate is splined on to the front end and retained by a circlip. Round the arc of this quadrant is a slot in which is registered a stud carried in a boss on the front of the timing cover. After the quadrant has been rotated to turn the eccentric and adjust the chain tension, a self-locking nut on the stud is screwed down on to it to fix the setting.

Four Vandervell, D2 bi-metal bushes are pressed into bosses in the crank webs and end walls to carry the En 32 camshaft. They are all 1.874-1.875 in internal diameter by 0.990-1.010 in long. The cams, journals, eccentric, and spiral gear driving the pump and distributor are carburized, hardened and tempered to a Rockwell hardness figure of C58-C62, and to such a depth as to give a minimum case thickness of 0.030 in after grinding.



The inlet rail is cored in the cylinder head

Axial location is effected by a two-piece thrust plate which is bolted to the front wall of the crankcase, and which engages in a $\frac{1}{4}$ in wide groove machined round the shaft.

The cam profiles have been designed to give the following characteristics at 4,700 r.p.m.: maximum positive acceleration of the tappet, on the flank of the cam, 9,354 ft/sec²; maximum negative acceleration, on the nose of the cam, 3,000 ft/sec²; maximum velocity 9.42 ft/sec. At the cam, the lift from the base circle to the nose is 0.285 in, and the nominal period is 121 deg without the silencing ramp. This ramp has a period of 34 deg both for opening and for closing.

Piston type tappets of chilled cast iron are employed. They are carried in a tappet chest cast integrally with the upper portion of the cylinder block. The bores in which the tappets are housed are 1.12375-1.12425 in diameter and the diametral clearance is 0.00045-0.00195 in. Since they are not perpendicular to the top face of the block, their upper ends are counterbored to facilitate the final machining operation.

In the base of each tappet is seated a $\frac{1}{2}$ in diameter hardened steel ball on which is carried the cupped lower end of the $\frac{1}{4}$ in diameter En 8 push rod. Both ends of each push rod are cyanide hardened to a minimum of 207 Brinell, and sand blasted to give an oil retaining surface. These rods are not vertical; those for the inlet valves are inclined at an angle of 17 deg from the vertical, whereas those for the exhaust valves are inclined at 23 deg from the vertical. The effective length of the inlet push rods is 8.15 in while that of the exhaust rods is 9.85 in. By employing the lighter rod to actuate the heavier valve, and *vice versa*, it has been possible to make one pair of springs common to both inlet and exhaust valves.

Vandervell Clevite bushes are pressed into the bores of the rockers. The polished end-pads of the rockers, which bear on the valve stems, are case hardened to a depth of 0.025-0.030 to give a Rockwell hardness figure of C58-C62. The $\frac{1}{8}$ in diameter, En 32

tappet adjusting screws are cyanide hardened, to a depth of 0.010 in, and their ball ends are polished. Both rocker shafts are of T26 steel tube and their inside and outside diameters are 0.310-0.315 in and 0.6233-0.6243 in respectively. Unbrako socket plugs are screwed into the ends of the shafts to seal them. Each shaft is carried on seven D.T.D. 424 aluminium die cast rocker pedestals, this material being employed in order partly to compensate for differential rates of expansion which might cause variations in tappet clearance. The distance between the valve stem axes of Nos. 1 and 2, 3 and 4, and 5 and 6 cylinders is 4.3 in, while between those of Nos. 2 and 3, and 4 and 5 it is 4.6 in. Other data relating to valve gear is given in the table.

Cylinder head, manifolds and carburetors

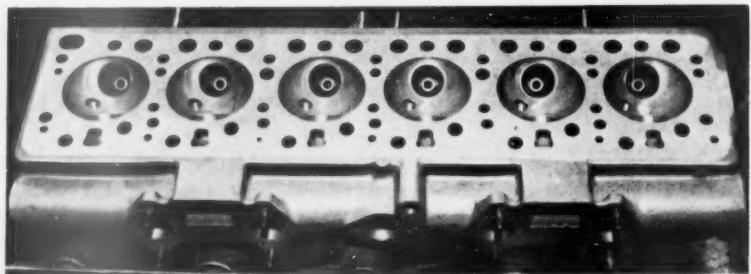
A B.S. 1452 grade 14 cast iron cylinder head is employed. The overall depth of the casting is 3.770-3.780 in and its overall width is 10.55 in. It is held down by fourteen $\frac{1}{4}$ in, B.S.F. bolts, of En 100T, on to a copper and asbestos gasket, the compressed thickness of which is 0.048-0.052 in. A Cooper EB cork washer forms the seal between the upper face of the head and the rocker cover. This cover is unusual in that it encloses both rocker assemblies, and is made from two 20 S.W.G. pressed steel shells which are placed one inside the other and separated by felt strips. It has rubber

grommetted holes in its top face, the grommets being fitted to seal round the tubes in which are housed the sparking plugs.

These tubes are vertically positioned, and each has a separate thimble end welded to its base; however, in future, it is intended that the ends of the tubes shall be spun over to form them to this shape. The whole assembly is a push fit in a socket in the top of the cylinder head, a copper washer being interposed between the thimble-end and the base of the socket. In the bottom of this socket is the sparking plug boss, and the plug is screwed down on to the usual copper and asbestos washer on the pierced thimble-end, and this prevents the tube from working loose as a result of vibration. A lip is formed round the top of the socket so that when the plugs have been removed, oil is prevented from running down through the sparking plug bosses into the cylinders, and causing a hydraulic lock when the engine is started again. The top of the tube is closed by a mushroom-shaped, plastics fitting, the stem of which is hollow and contains the plug lead and connection.

Hemispherical combustion chambers are incorporated in the head and each pair of valves is set, in a transverse plane, at an included angle of 70 deg. The axes of the inlet ports are turned through an angle of approximately 45 deg from the valve seats and the radius of curvature is 1.45 in, while the exhaust ports turn through approximately the same angle, but with a radius of curvature of 1.2 in. The water jacket is cored all round the exhaust valve guide housing, but only partly round that of the relatively cool inlet guide. Two separate cast iron exhaust manifolds are employed, each having three ports, and they are fitted in conjunction with Cemjo joint washers.

On the inlet side, an inlet rail or gallery is cast in the head and is joined by the six separate ports from the combustion chambers. The cast aluminium inlet manifold, on the other hand, has four branches which, of course, feed into the rail midway between Nos. 1 and 2, and 2 and 3 ports at the front, and 4 and 5, and 5 and 6 at the rear. Klingerit washers are employed between the manifold and the head. The front and rear portions of the rail are separated by a



Hemispherical combustion chambers are employed in this unit

$\frac{1}{4}$ in thick plate, in which is a $\frac{1}{4}$ in diameter hole that forms the balance aperture. A set bolt secures this plate perpendicularly to another which is bolted to the side of the cylinder head. Relative rotation between these two plates is prevented by a $\frac{1}{8}$ in diameter dowel. Below the inlet riser the manifold is water jacketed, and a fuel drain is incorporated at the lowest point. The crankcase breather system is connected to the induction air cleaner and silencer by means of a pipe from the oil filler neck on top of the rocker cover; and, on the right-hand side of the crankcase, an A.C. Delco air cleaner-breather unit is fitted.

With the single carburettor installation, a Stromberg DAV36 unit is mounted on an Incemjo insulating block, $\frac{1}{2}$ in thick, on the manifold. The choke diameter is $1\frac{1}{8}$ in, and the jet sizes are as follows: main (metering) jet 0.060 in, slow running (by-pass) jet 0.054 in, needle seating 0.100 in. When twin carburettors are fitted, they are the Stromberg DAA36 units, with a choke diameter of $1\frac{1}{8}$ in. The main (metering) jet is 0.058 in, and the power (by-pass) jet is 0.054 in. The needle seating is 0.100 in.

An A.C. Delco, series UE lift pump supplies fuel at a pressure of $1\frac{1}{2}$ - $2\frac{1}{2}$ lb/in². Fine gauze filters are fitted in the outlet from the fuel tank, the glass bowl on the fuel pump and in the carburettor union banjo bolt. The capacity of the tank is 16 gallons, and this includes $1\frac{1}{2}$ gallons reserve.

Water pump and cooling system

A fabric-reinforced rubber V-belt, with an included angle of 40 deg, transmits the drive to a cast iron pulley for the fan and water pump, which it drives at 1.105 times engine speed. Its overall dimensions are 0.390 in wide by 0.325 in thick. The pulley, together with the 14 in diameter, 4-bladed, 14 S.W.G. pressed steel fan, is spigoted and bolted on to a flanged boss pressed on to the 0.6262-0.6267 in diameter front end of the pump spindle. Positive location is effected by means of a grub screw inserted radially into the boss and engaging in a hole in the spindle. The assembly is statically balanced to within 7 inch drams.

A sealed tubular-type ball bearing, inserted from the front into the nose piece of the pump, carries the spindle. Location is effected by means of a dowel ended bolt which is screwed radially into the nose piece and which projects into a hole in the outer race. The inner races are formed by grooves in the spindle and their centres are spaced 1.06 in apart. In the space between the bearing and the water seal, no thrower ring is fitted but a drainage hole is drilled in its base.

The spring loaded water seal is

supplied by Super Oil Seals and Gaskets Ltd. It seats in a cup-shaped recess in the front of the rotor and has a moulded-in carbon thrust ring which bears against the front wall of the pump. This wall is part of the nose piece which is spigoted and bolted to the main body of the pump. Both the nose piece and the pump are of D.T.D. 424 and are anodized as a protection against corrosion.

Pressed on to the rear end of the spindle is a 2.95 in diameter stamped brass rotor. It is of the semi-shrouded type and discharges into a volute casing, which delivers coolant into a tube along the left-hand (exhaust) side of the top of the cylinder block jacket. Holes in the top of this tube direct the coolant up through cored ducts under the exhaust ports. From here, the coolant flows along the head and out past the thermostat to the radiator.

There is also a secondary circuit. In this the water passes out, through a thimble fitting pressed into the side of the cylinder head, into the water jacket, round the inlet manifold, and thence through another pipe back to the pump inlet. A rubber sealing ring round the shouldered outer end of the thimble is compressed by the manifold jacket cover plate when the assembly is bolted on to the head. The radiator is of the gilled tube type with brass tubes, and copper gills spaced $\frac{1}{8}$ in apart. It has a frontal area of 294 in², and four rows of tubes are accommodated.



The twin carburettor installation

dated in the block thickness of $2\frac{1}{4}$ in. An A.C. Delco pressure cap maintains the system at its operating pressure of 4 lb/in².

Oil pump and lubrication system

A Hobourn Eaton oil pump, driven at half engine speed, is bolted up to a boss inside the wall of the crankcase, near the rear. The bottom cover of the pump is positioned immediately above the sump oil level, but the suction port, which is cast integrally with this cover, is below this level. A short spindle, $4\frac{1}{2}$ in long by $\frac{1}{2}$ in diameter, is carried in the pump casing and pegged in the driving rotor. This spindle is waisted to 0.4980-0.4985 in

diameter for a length of $\frac{1}{2}$ in, below a point $\frac{1}{2}$ in from its slotted upper end.

The En 32, integral spiral gear and spindle, by means of which the pump is driven from the camshaft, is tongued at its lower end. It spigots into the pump casing and the tongue registers in the slot in the top end of the pump spindle already described. Accurate alignment of the two spindles has been ensured by spigoting the pump casing into its boss in the crankcase; the spigot hole in this boss is, of course, accurately aligned with the housing for the plain bearing which supports the upper end of this spindle and its spiral gear. In this bearing, the spindle diameter is 0.5985-0.5905 in, but between the bearing and the pump its diameter is 0.562 in.

A somewhat unusual upper bearing arrangement has been adopted, so that replacement may be easily effected. The journal loads are taken by a Clevite bush, $1\frac{1}{2}$ in long, pressed into a cast iron bush which takes the thrust from the spiral gear immediately above it. This bearing assembly is located in the boss by a conical ended set screw which engages in a tapered hole in the side of the cast iron bush. This set screw, which is inserted from outside the crankcase, is secured by a lock-nut.

The upper end of the gear is shouldered and bears against a phosphor bronze thrust ring located in a recess machined round the inner periphery at the base of the hollow turreted casting that carries the distributor unit. This turreted casting is of aluminium and is bolted and spigoted to a boss on the side of the crankcase. The drive for the distributor unit is formed by a $\frac{1}{8}$ in diameter, EN 8Q forged spindle, both ends of which are cupped. Its lower cupped end is tongued and registers in a slot in the top of the spiral gear. Spigoted into the cup at the upper end is the distributor spindle. A pin through the two components transmits the drive.

Oil is drawn through a floating pick-up in the pressed steel sump, which has a capacity of 10 pints. It discharges from the pump through a duct in the casing into a chamber formed by coring the sump casting between the bosses for the pump spigot and the pump bearing. This arrangement, of course, provides for the lubrication of the upper and lower bearings of the pump drive spindle. A small groove machined along the bore of the upper bearing housing directs a jet of oil on to the spiral gear. The positive supply of oil to the upper bearing is a noteworthy feature of this unit; in many designs this bearing is inadequately lubricated and in some cases it tends to squeak. From this chamber, which surrounds the upper drive spindle, the lubricant is passed

through the full flow filter and thence to the $\frac{1}{2}$ in diameter gallery. It then goes through $\frac{1}{8}$ in diameter passages between the crankshaft main journal and camshaft bearings. Ducts are drilled in the usual way in the crankshaft to carry oil from the main journals to the big ends. The arrangement of the adjustable relief valve which, when the engine is warm, blows off at 40 lb/in², and the layout of the ducts serving it, which are in the rear intermediate bearing web, may be seen in one of the scrap views shown in the illustration of the engine cross sections.

The transverse drilling in the front wall of the crankcase is joined by two more holes. One of these carries oil into an axial drilling in the spindle of the jockey sprocket for the timing chain, and thence through a radial hole to lubricate the bearing surfaces. The other serves the thimble jet, screwed into the front wall of the crankcase, which directs oil into the meshing point between the timing chain and the drive sprocket.

An intermittent feed to the rocker

gear is taken from No. 2 camshaft bearing, in which a flat is machined in such a position on the journal that once every revolution the oil feed to the bearing is connected with a vertical drilling up through the crankcase, cylinder head and No. 3 pedestal, whence the oil passes into a hole drilled diametrically through the hollow inlet rocker shaft. A banjo bolt registers in the upper end of this hole to locate it and to carry the oil through an external pipe to a similar banjo connection on No. 3 pedestal of the exhaust shaft.

From the interior of both shafts, radial drillings serve the rocker bushes. The bores of each of the bushes are grooved and drilled to pass oil through a hole in the rocker, which communicates with an annular space round the waisted, tappet adjusting screw. From this space, a radial and an axial drilling in the screw pass the oil down to lubricate the spherical contact faces between it and the push rod end. Lubrication of the other end of each rocker is provided for by a $\frac{1}{2}$ in diameter hole drilled, from a point

between the upper and lower flanges of the I-section arm, radially through the boss and into the oil groove in the bush. The valves are inclined at such an angle that it is not necessary to take any special precautions to prevent oil running down their stems.

Electrical equipment

Lucas 12 volt electrical equipment is used throughout. A GTW11A battery of 64 amp-hr capacity is employed. It is served by a C45 PV5 dynamo operating in conjunction with an RB 106/1 voltage regulator and cut-out. The system is protected by a SF6 fuse unit. An M45G starter motor with a 10-tooth pinion engages the 142-tooth ring gear. The contact breaker and distributor unit is the DMX 6A. A centrifugal and vacuum operated advance and retard mechanism is incorporated, and supply is from a B12 coil. Champion N8B, 14 mm, long reach plugs are fitted. Other electrical equipment includes PF770 head lamps, 464 tail, stop and reversing lamps, dual tone WT614 horns and SF80 trafficators.

SWARF SEPARATION

THE present high cost of non-ferrous materials makes it essential that, for the sake of economy, swarf reclamation shall be as complete as possible. In the case of organizations that operate their own foundries, the reclaimed swarf must be completely free from ferrous materials, while if the swarf is to be sold as scrap its value is greatly increased if it is free from iron contamination.

In the machine shop there is usually the possibility that some mixing of ferrous and non-ferrous swarf will occur. Fortunately, the swarf can readily be separated in a magnetic separator of the drum type. This machine has horizontal magnet poles

so that as the swarf is fed on to the drum the iron particles form up in rows across the drum. During the rotation of the drum the non-ferrous material passes forward but the ferrous material clings to the drum along the lines of the magnetic poles.

Several ribs are fitted to the drum. As they move forward the non-ferrous material is pushed away from the magnetic pole and in jumping to the next magnet bar it turns completely over. By this means any non-ferrous material that may have been trapped is released. In practice a drum would normally have six sets of magnet bars, so that by the time the swarf has passed over the drum there is complete

separation of ferrous from non-ferrous material.

Two disadvantages of this type of equipment have been the high feeding height and the necessity for having cams at the back of the feed tray to jolt down the material, which does not flow freely. With this arrangement there was excessive noise and continual wear on the cams. To overcome these drawbacks The Magnetic Equipment Co. Ltd., Lake Works, Portchester, Hampshire, have developed the Magco feeder for use with their magnetic separators. This feeder has no moving parts. It has lowered the feeding height to 40 in and reduced the noise level to a very low value. (2051)

HARD CHROMIUM PLATING OF ALUMINIUM

AN article entitled "Hard Chromium Plating of Aluminium," by E. Meyer-Rassler, has been published in *Metall*, Vol. 6, No. 17/18. The author states that the resistance of aluminium and aluminium alloys to mechanical wear can be greatly improved by hard chromium plating. This process is especially suitable for engine cylinders, because the chromium possesses good corrosion resistance and radiation properties, as well as offering a low frictional resistance. To obtain good adherence between the aluminium and the chromium plate, however, a pre-treatment of the light alloy is regarded as essential.

Methods of pre-treatment may be chemical or mechanical, and aim at

removing the aluminium oxide skin, and producing a roughened substructure to which the chromium can be firmly attached. Etching processes using an alkaline zincate solution, and then a nickel chloride solution have proved satisfactory. Wet sand blasting is not suitable as it leads to inferior adhesion of the plate.

The plating process can be performed in baths of the same composition as those used for plating steel and iron. Grinding and honing may be used for finishing. In the production of chromium plated aluminium cylinders, a chromium layer 0.10-0.15 mm thick has practically no effect on the thermal conductivity of the unit. Therefore, before plating, the bore size is machined

to about twice the plate thickness, or 0.2 mm. oversize, so that the nominal diameter will be obtained when the process is complete. Experiments are necessary to determine the best plating arrangement for each type of cylinder.

To give better oil-retaining properties to the smooth chromium plated surface, pores and indentations may be produced by chemical, electro-chemical, galvanic or mechanical means. Honing is minimized by keeping the thickness of the plate to 0.10 mm. In series production, cylinders are classified in variations of 0.005 mm in size, so that pistons may be selectively assembled. During service, used cylinders may be stripped of chrome and replated. *M.I.R.A. Abstract No. 6350.*

LOW-PRESSURE LAMINATES

Physical Properties: Design Considerations: Moulding Methods: Resin-impregnated Asbestos-fibre and Glass-fibre Materials

Richard Wood

THE use of reinforced plastics in the automobile industry is not new and for a number of years materials consisting of a filler bonded with resin, in many cases under conditions of heat and pressure, have been used experimentally for body construction. More recently, with developments in the resin field, attention has been devoted to the study of suitable reinforcing materials and a considerable amount of development work has been carried out with fillers of asbestos, glass-fibre and a number of synthetic fibres such as nylon and terylene. Of these materials, the fillers that would appear most suitable for body construction are asbestos-fibre and glass-fibre. The nature and application of these two types of plastics materials have been discussed in *Automobile Engineer* for June 1952. Although certain of these materials have been available for some time and a number of experimental bodies have been built, it is possible that many of the advantages to be gained from their use have not, hitherto, been apparent, due to the fact that aluminium and steel have proved adequate, both economically and in production, for the construction of the more conventional types of body.

Properties

By reference to Table I, in which are set out some of the physical properties of reinforced laminates and traditional materials, comparisons are possible. At a first glance the specific properties of the reinforced plastics would appear to be low and it would seem doubtful if their use as structural materials would be advantageous. Each of these materials, however, possesses a quite distinct range in which it can be used efficiently and over the lower

Reinforced plastics laminates have received considerable attention during the past few years as possible alternatives to traditional materials for automobile body construction. As with many new materials, the reception of plastics has, in some cases, been over-enthusiastic, whilst in others, their application has been viewed with undue pessimism.

With a clear appreciation of their characteristics, these materials should be capable of selection and should prove a useful, if not revolutionary, addition to the constructional materials at the disposal of the automobile engineer.

ranges of loading, high efficiency structures from a viewpoint of strength: weight ratio can be designed.

In consideration of any design, torsional stiffness is of considerable importance and whilst these materials may not show to advantage in all cases, it has been found that due to a high strength:weight ratio, adequate stiffness can be obtained by designing for the use of the materials and not merely endeavouring to reproduce conventional structures without modification. Other advantages to be taken into consideration are low final cost which is particularly marked in the case of small quantity production due to simplicity of the tooling required and the fact that by careful design complex structures can invariably be produced as a single moulding, thus eliminating assembly time.

Among other advantages are good heat and sound insulation and an exceptionally high shock-absorbing property. This property is particularly important in an automobile body and greatly assists in localizing any damage in the case of a minor accident.

An additional factor of importance in

assessing the suitability of plastics as structural materials, is that contours which are difficult and expensive to produce in metal can be moulded with ease. In fact, it would seem that the development of plastics is opportune in view of the tendency toward one-piece bodies and the introduction, on the part of the stylist, of re-entrant curvature. From the point of view of road performance, plastics offer advantages in weight-saving, not only from their high strength:weight properties, but also due to the fact that as the materials consist of a number of layers of reinforcement, the strength of a structure can be controlled readily by the variation of the number of plies over a given area. In this way a body can be given high strength where stresses are high and yet need not pay a weight penalty when stresses are low.

Laminates also offer distinct advantages inasmuch that they are corrosion- and water-resistant and do not require extensive pre-finishing treatment. The operation is largely dependent upon the method of moulding adopted but, in many cases with a correct moulding technique and the application of a suitable mould-release agent, the treatment can be reduced to a minimum if not dispensed with entirely.

In the field of glass-fibre reinforcement, considerable work is being carried out with moulded-in colour and bodies have been produced which do not require painting. The process, however, is not yet entirely satisfactory from a commercial viewpoint due to the fact that the colours available are slightly transparent and the weave of the reinforcement can be seen. Although not without advantages for certain parts such as, perhaps, facia boards, sun-visors and internal trims, the development of opaque colours is a

TABLE I. STRENGTH OF SOME LAMINATED PLASTICS AND METALS

	Specific gravity	Tensile strength (lb/in ²)	Compressive strength (lb/in ²)	Shear strength (lb/in ²)	E (lb/in ² × 10 ⁶)	Specific	
						Tensile strength (lb/in ²)	E (lb/in ² × 10 ⁶)
Durestos	1.27	15,250	13,000	5,000	2.0	12,000	1.57
Gordon Aerolite	1.43	70,000	34,000	2,000	7.0	49,000	4.89
Glass fibre (polyester)	1.82	43,000	42,000	8,000	3.0	23,600	1.65
Kraft paper (phenolic)	1.47	30,400	25,800	4,500	2.1	20,700	1.43
Duralumin	2.8	60,000	60,000	36,000	10.0	21,400	3.57
Mild steel sheet	7.8	45,000	45,000	22,000	29.0	5,800	3.7

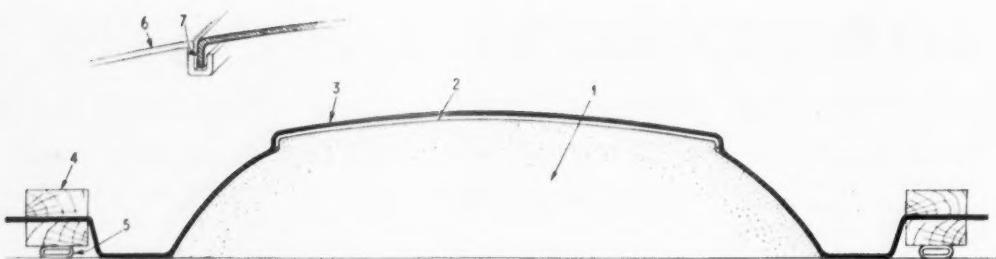


Fig. 1. Semi-diagrammatic view through a male-type vacuum-mould showing one method of moulding an engine access panel. Detail shows the method of moulding drip-edging

necessity if the technique is to be used commercially to replace cellulose and synthetic enamel for body exteriors.

On the debit side, plastics are expensive when compared with traditional materials of construction. Raw material costs, although showing some reduction, are high and production processes at present available, for large mouldings in particular, are time consuming. Output of raw materials, although increasing, is still comparatively small but with a greater demand it can be expected that prices will be further reduced.

Asbestos-fibre reinforcement

As previously described, asbestos fibre reinforced plastics are available commercially in the form of pliable felts which are impregnated with phenol-formaldehyde resin. This resin is thermo-setting and is of a two-stage type, that is, its cure takes place in two phases under the influence of heat and pressure. During manufacture the resin is brought to the first stage, so that after moulding, further application of heat and pressure brings about the final cure. It is of some interest to note, however, that although in production the application of heat and pressure is required to cure the resin thoroughly, the store life of the felts is not infinite due to a slow polymerization of the resin which starts and continues slowly from the time of impregnation.

A characteristic of the resin is that its cure is accompanied by a process of chemical condensation with the liberation of water which, to permit the resin to set, must be removed during the curing process. Until recently, this consideration has been one of the greatest obstacles to the use of phenolic-impregnated laminates for the manufacture of structures such as car bodies due to the prohibitive cost of the large, heated pressure-moulds necessary to the dispersion of the products of condensation. An additional problem in the use of phenolic-based felts, particularly in structures embodying a number of plies of the material and moulded without pressure, is that of the lifting of the plies due to liberated moisture.

Recently, to avoid the cost of large moulds, methods have been developed which largely overcome the necessity for the application of pressure. These

methods, which are known as vacuum and no-pressure moulding, have permitted small quantity production of large structures to be carried out economically, and considerable experience has been gained in the handling and the application of the material.

During moulding it has been found that the asbestos-felts become soft and pliable as temperature is increased, and in this state very little pressure is required to consolidate them to each other and to the form of the mould. In this way, successful moulding can be achieved by ensuring that the folds are brought into intimate contact with one another and with the mould, and by continuously venting the mould during the curing period to disperse the products of condensation.

No-pressure process

The no-pressure process of moulding asbestos-phenolic material, which is based upon the foregoing, relies for its successful application upon a number of simple principles. Briefly, these principles are, the softening of the felts prior to laying-up, adequate consolidation of each layer, the application of a suitable adhesive between each layer, the provision of some form of internal restraint to prevent springback, and the provision of a suitable catalyst to enable the resin to cure at a sufficiently low temperature to minimize the vapour-pressure of the water given off.

Softening of the felts, it has been found, can be carried out conveniently by the application of warm water immediately prior to the commencement of the lay-up process. Consolidation of the felts is carried out in two stages, firstly with a narrow roller by which a heavy, local pressure can be applied, and secondly, by the use of a wide rubber squeegee to iron out variations in the thickness of the felts and to enable excess water to be removed. The application of an adhesive between each layer of felt to increase the homogeneity of the laminate is necessary because as the felts are cured without the pressure, adhesion between each layer is poor.

The need for providing some means of restraining the felts internally and the presence of a catalyst to reduce the curing temperature of the resin can be met by the use of a suitable adhesive. For this purpose a modified resorcinol-formaldehyde glue has been developed.

This glue is available in proprietary form as Aerolite 185*, which is activated for use by the addition of a small quantity (one-fifth by weight) of paraformaldehyde and when the glue has been mixed 1-2 per cent of furfuryl-alcohol is added. The addition of the alcohol, which is an excellent wetting agent, facilitates the dispersion of the glue into the fibres of the asbestos felt. Additionally, the modified resin gives considerably greater shrinking properties than the unmodified resin, and, in this way, serves to hold the layers of felt together during the curing process. The third advantage accruing from the use of modified Aerolite 185 resin is that when it is mixed with phenolic-resin, it has the effect of reducing considerably the temperature required for curing.

The actual lay-up of a component is comparatively simple and can be carried out after practice by a semi-skilled operator. The felt, after being cut to size—a standard bandsaw is suitable for cutting the felt—is damped on both sides with water at approximately 70 deg C. The felts are then laid in position on the mould and the first layer is compressed to the form of the mould by the use of the smaller of the two rollers. The second roller is then brought into use to expel excess water, and the outer surface of the felt is coated with the modified resin. The second felt is then placed in position and the process is continued until a laminate of the required thickness has been built-up.

An important consideration in the tailoring of the felts is that the cuts are made in such a way that adjacent edges can be butt-jointed and overlapping edges avoided. It has been found that when the felts are wet it is comparatively simple to bring excess material into the form of a fold which can then be cut off close to the former.

Low-pressure or vacuum-moulding

For the larger-scale production of small parts, manufacturing costs can be reduced in many cases by the use of a low-pressure moulding technique. These techniques are many and varied and are based upon the application of a low pressure upon the surface of the work during the curing period.

In vacuum-moulding, atmospheric

*Manufactured by Aero Research Ltd., Duxford Cambridge.

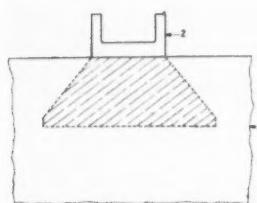


Fig. 2. One method of incorporating metal attachment points in a laminate

produce a superior and more consistent surface finish. Male moulds are particularly suitable for the production of prototypes as modifications and additions to the contour of the work can be incorporated readily and with the minimum of cost. Female moulds are preferable for quantity production and, as will be discussed later, are usually provided with means for heating the laminate to reduce curing time.

Materials suitable for moulds are many and various and include plaster, cement, and metals. The selection of material for moulds is mainly dependent upon the moulding process used and the size and the nature of the work. Where quantity requirements are small and not sufficient to necessitate the use of heated moulds, plaster can be used with success. For certain types of

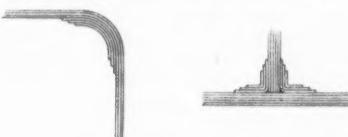


Fig. 3. A method of reinforcing bends and joints by additional piles of impregnated felt

work, low-melting-point alloy offers many advantages and can be used for the low-quantity production of small one-piece mouldings in which the form of the part precludes the withdrawal of the work from the mould.

Mould heating

In the simplest forms of mould, heating of the work to effect complete curing of the resin is by means of an oven in which the charged mould can be heated for a predetermined period. In some cases mould temperature can be maintained by means of induction-heating. Large moulds, particularly those of concrete, are usually heated by a number of resistance-type elements which are embodied in the mould during manufacture. They usually incorporate a series of thermocouples

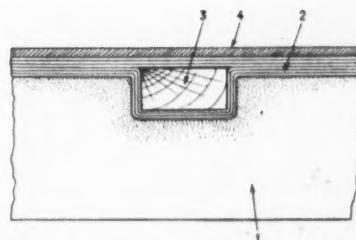
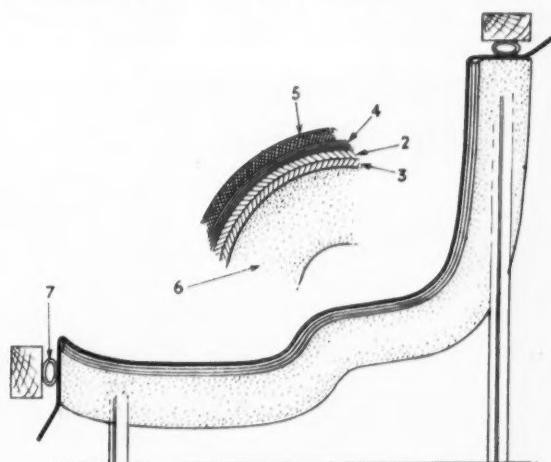
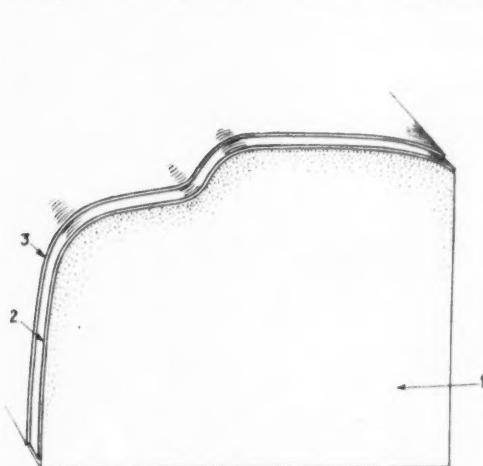


Fig. 4. Section through a male-type mould showing a method of embodying wood or metal inserts

to indicate the temperature conditions within the mould.

The vacuum-bag process has a wide range of application and can be used for the production of both large and small parts such as seats, facias, floor members, boot lids and bonnet lids. An example of one method of moulding a bonnet lid is shown semi-diagrammatically in Fig. 1. When used for quantity production of a number of similar parts upon male moulds, handling time can be reduced by curing a number of parts simultaneously upon the vacuum table. One factor of importance that must be taken into consideration when moulding a number of parts at the same time is the spacing of each mould or form block to ensure that the rubber blanket is not subject to excessive local stretching as the vacuum is applied. The resilience of the rubber blanket must also be taken into consideration in the design of tools for use in the vacuum process. Sharp corners should be avoided and ample radii and fairing on the lower edges of the tool should be provided to avoid undue stretching of the rubber.

Among advantages of this method of moulding is the ease with which stiffeners and inserts can be incorporated during the laying-up process. Although stiffeners and attachments of asbestos and other materials can be bonded successfully to the laminate



1, Model; 2, Intermediate liner; 3, Mould liner; 4, Laminate; 5, Rubber blanket; 6, Mould backing; 7, Sealing tube.

Fig. 5. (Left) Semi-diagrammatic section through a plaster model showing the position of the mould liner and the intermediate liner. (Right) Section through the completed mould with the rubber blanket sealed at its edges and under vacuum

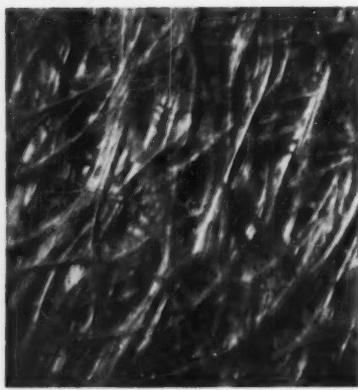


Fig. 6. Chopped-strand mat. Scale 1 : 1

after it has been cured, where possible the attachment should be completely bonded-in and cured with the laminate. In this way superior strength is usually obtained and the insert, particularly if it is of metal, is not exposed to corrosion or rusting. The surface treatment of metallic inserts prior to bonding has received considerable attention recently and will be dealt with in more detail later in this article.

Mould liner

Recently the vacuum-bag method of moulding has been modified and for the production of large structures has been used in conjunction with a detachable mould liner. Moulding is carried out in a female mould, usually of concrete, under conditions of heat and pressure. In this process, the contour of the mould is obtained from an accurate model of the part which is used for the production of a phenolic-impregnated asbestos liner. This liner is detachable from within the mould itself and it will be appreciated that, as it is moulded from the model, its inner surface corresponds faithfully to the surface of the mould and this surface is, in turn, reproduced upon the outer surface of the part itself.

For the production of an accurate moulding, the use of an intermediate-liner is not essential as the layers of

felt that comprise the moulding could be positioned directly within the mould. However, the use of an intermediate liner, in which the felts can be laid-up before being loaded into the mould, ensures that the assembly cannot adhere to the surface of the mould during curing and, upon completion of the process, that the moulding can be removed without damage to itself or to the mould face. The complete mould, therefore, is composed of two parts: an inner lining of asbestos felt into which the intermediate liner is fitted, and an outer portion or shell of cement which stabilizes the asbestos-lining and serves as an abutment for sealing the edge of the rubber-bag that is used to compress the felts during the curing process.

It will be readily appreciated from the foregoing that the use of an intermediate liner ensures that in the event of adhesion between the work and the mould, the mould itself does not suffer damage and it is merely necessary to replace the liner.

The heat necessary to ensure complete curing of the moulding is obtained in this type of mould by resistance-type elements which are built into the mould during its manufacture. For the majority of work it is advantageous to heat the moulding from both sides during the cure and for this purpose a second series of heating elements woven on glasscloth blankets are placed on the inner surface of the felts after the assembly has been placed in the mould. Temperature conditions within the mould during the curing period are critical and to enable accurate control to be maintained during this period a number of thermocouples are usually embodied in the mould.

In equipment recently developed in the aircraft industry, a very large number of thermocouples were incorporated and to permit each thermocouple to be read at the required frequency, the temperatures are recorded automatically upon a chart.

Master-models can be made of a variety of materials, including plaster, wood and cement. For the majority of

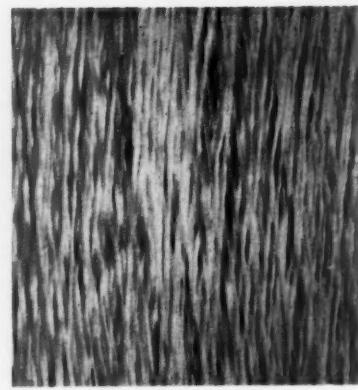


Fig. 7. Diamond mat. Scale 1 : 1

large work, plaster is usually the most convenient as it can be built-up on a wood or metal framework and can be finished to a smooth contour with ease. The contours of the master-model can be determined by the use of templates which are set-up at the required stations before plastering is commenced. Fairing of the model between template stations can then be carried out by the use of a spline in the usual way. The production of a smooth finish of accurate contour on the surface of the model is facilitated by the use, as a final covering, of a slow-setting plaster such as Keene's cement which permits work to be carried out on the mould for a period of some hours. It is well known that, if required, the setting period of the plaster can be extended by the addition of certain salts which are dissolved in the plaster while it is being mixed.

Intermediate liner

The next stage in the preparation of the complete mould is the production of the intermediate-liner. As previously mentioned, this liner is made of impregnated asbestos felt and is moulded over the model by the vacuum-bag process. To ensure release of the liner at the completion of the curing process, the surface of the model is treated with a parting agent—usually a grease containing a small percentage of silicones—before the felts are placed in position.

The mould itself consists of a number of layers of impregnated asbestos felt in which are located the heating elements and the thermocouples. The contour of the mould is obtained from the model in a similar manner to the intermediate liner. The investment of the mould in concrete to provide stability offers few problems, but difficulty has been experienced in preventing loss of vacuum in the mould during the curing process due to the porous nature of the concrete. To overcome this difficulty, it has been found advantageous to spray the outer surface of the mould with a vinyl emulsion to close the pores in the cement.

The operation of charging the mould can be performed by hand in the case



Fig. 8. Experimental body in glass-fibre/polyester resin with tubular steel reinforcement. Produced on an expendable plaster mould

of small mouldings and consists of laying each felt, in turn, in the correct position within the intermediate liner. Before being assembled, resin is applied to the surface of each felt. The charging of large moulds presents greater difficulty due to the problems of handling the prepared felts. Charging of these moulds, it has been found, can be greatly facilitated by the use of a loading-fixture over which each prepared felt can be draped in turn, and on which the assembly can be conveyed into the mould.

When the mould has been charged and the rubber vacuum-bag has been placed in position, it is sealed at the edges to prevent loss of vacuum. Provision for sealing usually takes the form of a rubber hose which is held by means of clamps against a smooth locating face on the edge of the concrete mould itself. The efficiency of the seal can be increased by making the hose endless and inflating it from the shop air line.

The average curing time for phenolic-asbestos felt varies widely. In the application described here, the curing period is approximately 6 hr in duration and is carried out in three stages. The first stage in the curing consists of raising the temperature to about 160 deg C at a rate of 70 deg/hr. In the second stage the temperature is maintained for a period of approximately 1 hr, after which the temperature is slowly reduced until the mould reaches room temperature.

It will be obvious from the foregoing brief review of moulding methods that the problem associated with the use of phenolic - impregnated asbestos felt material for the construction of automobile bodywork, except perhaps for the specialist coachbuilder, is the length of time required to complete the curing operation. Problems of tooling and material handling, although somewhat different from those asso-



Fig. 9. Singer Roadster body moulded in glass-fibre/polyester resin

ciated with more conventional methods of construction, should present little difficulty. From that aspect, it should be possible, with ingenuity, to speed-up the moulding process to the level required for medium production. The problem of curing, however, remains all important. Recently considerable development work has been carried out in this field and it has been found that the time required to cure a laminate of phenolic-impregnated asbestos can be reduced to approximately one-fifth the time normally required, by passage of an alternating current. This process, which at present is still in the development stage, has been termed shock-curing. The theory of the process is not yet fully understood but it is thought that the current may serve as a catalyst, or that polymerization is carried out more rapidly by an orientation of the molecules.

In the majority of the experiments carried out, specimens of laminate have been compressed between polished copper platens at a pressure of approximately 120 deg C. Under these conditions an alternating current

at a pressure of 50 V caused the temperature of the laminate to rise to between 160 deg and 200 deg C. In one of these tests a specimen of laminate was cured in a period of 20 min. The current, which in this case was 230 V, flowed for a period of from 5 to 10 min; the remainder of the time being taken in raising the laminate to the triggering temperature. As would be expected for a given material, the higher the voltage the more rapid the cure. In view of these developments it may well be that the solution to the problem of obtaining a rapid curing cycle lies in a modified form of shock-curing.

As a preliminary to reviewing the application of glass-fibre reinforced laminates in the automobile field it is advantageous to consider, briefly, the nature of the materials available as reinforcement and the properties of the various types of laminate that can be produced with them. Reinforced low-pressure laminates, as distinct from other fibre-filled plastics, are virtually tailor-made materials, inasmuch that their characteristics can be varied over quite wide limits to give properties suitable for a great variety of products.

In principle, all low-pressure laminates are produced by impregnating a number of layers of reinforcing material with a resin which is usually of a cold-setting type. Laminates produced in this way are analogous to a matrix such as reinforced concrete; each fibre being embedded in a tube acts as a reinforcing rod. While the primary purpose of the resin is to bond each of the individual fibres together, it does not contribute to any very great extent to the tensile strength of the laminate although, to some degree it does increase the stiffness of the structure.

As previously mentioned, one of the advantages of this form of construction is that the contours of the work are not limited in complexity by considerations of what can be produced economically under the press or drop-hammer, and the strength of the structure can be varied readily over any desired area by the number of plies of reinforcing material that are embodied in the lay-up.

For the preparation of low-pressure

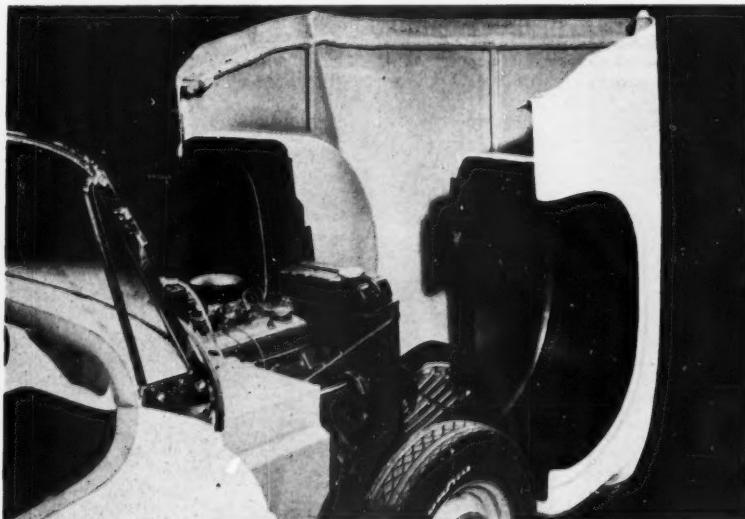


Fig. 10. The front portion of the Singer Roadster body in the open position, showing details of the tubular stiffening-members

laminates the use of a contact resin which will cure without the use of heat, or heat and pressure, is particularly attractive to the automobile body engineer. It eliminates the need for the heavy, heated presses and hydraulic systems which have been a necessity for the production of high-pressure laminates. The capability of working at low- or contact-pressures makes possible a wide variation in the method of laying-up the reinforcing plies and the comparative simplicity of the tooling required permits small numbers of a part to be produced economically and allows greater flexibility of design to be obtained.

Types of glass-fibre reinforcement

Glass-fibre reinforcement is available in a number of forms including cloth and woven and non-woven mats. Basically, all forms of reinforcement consist of a number of extremely fine glass filaments which are produced by melting glass nodules in an electric furnace and drawing the molten glass from holes in the base of the crucible by means of a high-speed winder. The filaments are then twisted and doubled to produce a yarn from which cloth can be woven or are wound parallel to produce a roving.

Cloths are basically of three types: a plain weave, in which each warp and weft thread passes over one thread and under the next, satin weaves which consist of four, six or eight shafts and in which each warp and weft passes under one and over a number of threads according to the particular type of cloth, and unidirectional cloths which have weak weft threads and strong warp threads to give maximum strength in one direction. The properties of cloth laminates vary widely with the weave of the cloth. In the main, laminates with the highest overall mechanical properties are those prepared from a large number of very thin plies or by the incorporation of thin plies in the outer surfaces. From this it will be apparent that the strength of laminates decreases with increase in



Fig. 11. A view of the Singer Roadster door showing the lock mounting and the method of obtaining edge-stiffness

the thickness of the individual plies. Impact strength, however, which is possibly of greater importance to the automobile body manufacturer, increases with the thickness of cloth.

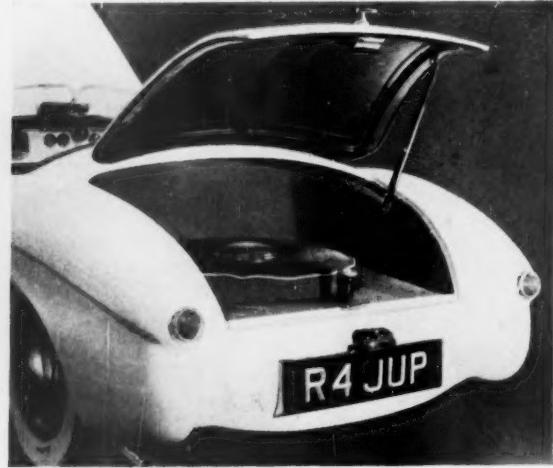
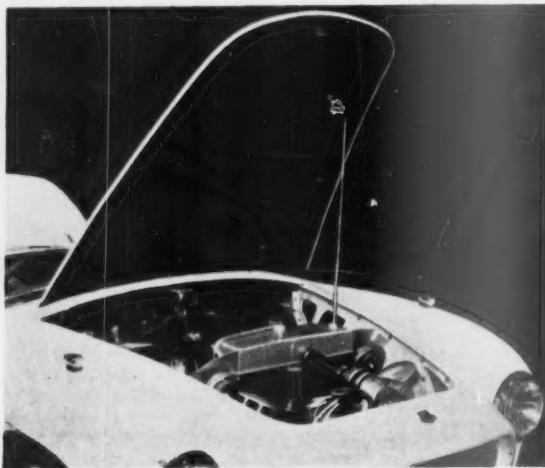
Briefly, therefore, the choice of fabric is dependent upon the design requirements. The advantages of each type of cloth may be summed up as follows:—plain-weave cloths offer advantages where uniformity of strength is required in two directions, usually at right angles, and where thicker cloths are used to facilitate deep drawing and the removal of air pockets when laminating by contact or vacuum methods. Unidirectional cloths find application where the requirements of the laminate are maximum strength in one direction, maximum strength:weight ratio, and where localized areas necessitate additional stiffness or impact resistance.

Long-shaft, satin-weave cloths are used for parts that require high strength in all directions combined with light weight. These cloths permit high-strength laminates to be produced at a lower cost and give a smooth surface finish.

Mats for use as reinforcement are of two types, those with non-orientated fibres and those with fibres that are laid in a diamond pattern. Chopped-strand or non-orientated mats give good multi-directional strength properties and are somewhat cheaper than diamond mats of comparable thickness. A further form of reinforcement is roving which, as previously mentioned, consists of a number of untwisted filaments. This material can be used for local stiffening and can be chopped into short lengths for use in preform moulding, which will be referred to later in this article. Although the surface finish obtained is dependent largely upon the method of moulding and the filler adopted, the finish on mouldings can be improved materially by the use of a special surfacing-mat which is incorporated in the surface of the laminate. This mat consists of a thin sheet of randomly distributed fibres of relatively large diameter which hold a comparatively large percentage of resin and thus gives a smooth finish.

Flexibility of styling

As previously mentioned, the fact that low-pressure laminates can be produced on simple tools permits a flexibility of design to be achieved that is not possible with a pressed-steel body. Although one of the most important characteristics of reinforced plastics is their suitability for one-piece bodies, it is yet too early to forecast what form bodies will take. A number of one-piece bodies have been constructed but, in this country to date, development on these lines has been carried out in the main by the amateur builder. Basically, the production of a one-piece body, unless of exceptionally simple shape and completely devoid of all under-cuts, necessitates the use of



Figs. 12 and 13. The Jowett Jupiter body is a composite structure. Bonnet and boot lids are of moulded construction, stiffened internally with top-hat section ribs

an expendable male mould, or a split female mould.

In the experimental body, Fig. 8, now being constructed by the writer for the purpose of developing methods for producing a closed body of exceptionally light weight, the lines of the body were conceived as an ideal and no concessions were made to the problems of removing the body from the mould. For this reason it was necessary to lay-up the body shell on a plaster male mould that could be broken out when the curing of the resin was complete. For the production of more than one body of similar or equally difficult contour the use of a split female mould would overcome difficulties due to undercuts and areas of return curvature.

Prototypes

The expendable plaster male mould, however, has been used to some advantage commercially by manufacturers in the U.S.A. for the production of prototype bodies for the purpose of obtaining decisions on such questions as styling, seating capacity, colour and accessories. Hitherto, the medium used for this purpose has been a clay or plaster. These materials have many disadvantages, chief of which is their weight and consequent difficulty of transportation and the problem of obtaining an accurate representation of chromium-plating on parts such as bumpers and screen pillars. Glass-reinforced plastics, it has been found, is an almost ideal material for this purpose, as an accurate representation of proposed bodies can be produced cheaply and the high strength:weight ratio of the moulding permits the structure to be transported with ease. Moreover, little difficulty is encountered in plating and painting.

Corrosion

The high corrosion-resisting and water-resisting properties of glass/polyester laminates is of particular value in automobile bodies, especially for those exported to maritime countries and localities where high humidity conditions accelerate corrosion and oxidization of alloy and steel bodies. Furthermore, the excellent thermal-insulating properties of glass/resin laminates is of marked value in countries having extremes of climate.

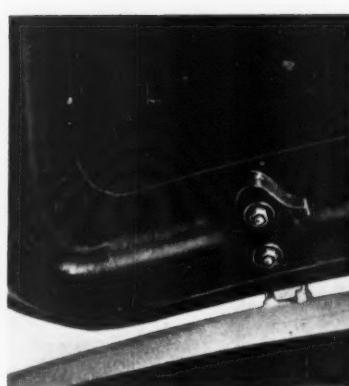


Fig. 14. Close-up view of the Jowett boot lid showing details at one of the hinge attachment points

As will be appreciated, the use of double-skinned panels, particularly for roof structures, materially increases the thermal efficiency and for hot climates the incorporation of a white-pigmented filler in the resin used for bonding the outer plies of the roof can effect a considerable reduction in the temperature of the interior of closed bodies.

Fire-proofing

An important consideration from the point of view of the automobile body engineer is the fire risk of non-metallic materials. Broadly, glass/polyester resin laminates do not support combustion although they will burn if subjected to the heat of a continuously applied flame. It will be appreciated that combustion is confined only to the resin content, the glass-fibre reinforcement being an inactive constituent. Complete fire-proofing of the laminate, however, can be achieved by the addition to the resin during the mixing operation of a small percentage of comparatively inexpensive materials. The fire-proofing material found most suitable, is a mixture consisting of 15 parts by weight of Cereclor 70* and 15 parts by weight of antimony oxide. In mixing these materials, the Cereclor is dissolved in the resin first and the antimony oxide ground into the mixture afterwards. The addition of fire-proofing materials

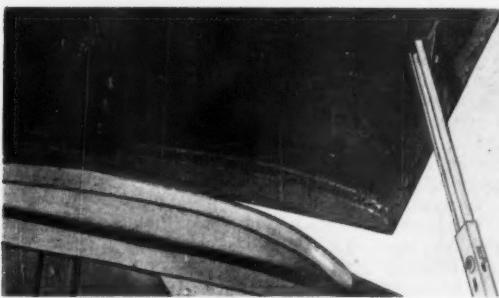
usually increases the setting time of the resin somewhat, but if the oxide is dry the increase is not considerable.

Design considerations

As previously mentioned, one of the most important advantages of glass-reinforced plastics is the ease with which complex curves can be produced, as compared with panel beating. If full advantage of the physical properties of the material is to be obtained, however, each application must be carefully studied in relation to traditional materials. Although possessing a high strength:weight ratio, the specific stiffness of glass-fibre resin laminates is comparatively low and reaches only about one-third that of many of the aluminium-alloys and steel. This fact largely governs the design of laminated structures and imposes upon the designer restrictions not present with metal. Stiffness requirements can be met largely in design by the avoidance of flat panels and the incorporation, where styling considerations permit, of double and return curvature. In the majority of bodies, however, there are usually a number of areas where the use of pronounced double curvature is precluded and the incorporation of stiffening ribs on the inner surface of the panel has been found satisfactory in reducing "oil canning" effects over these areas.

Although the majority of manufacturers in this country are following the development of reinforced plastics with interest, to date these materials have been used on very few production cars. At the recent Exhibition held at Earls Court, the Jowett Company showed a composite body in which the front wings, engine access panel and boot lid were of moulded construction and the Singer Motor Co. Ltd. showed a Roadster body moulded completely in resin-impregnated glass-fibre. The Singer body consists of four main units, the body aft of the scuttle and including the rear wings, the bonnet, radiator cowl and front wings, and off-side and near-side doors. The forward portion of the body is hinged at the front cross-member and can be raised to facilitate access to the engine and front suspension. The facia also consists of a glass-fibre moulding. It is interesting to note that in this, the first production body to be made in this country, steel

*I.C.I. Ltd., Plastics Division, Black Fan Road, Welwyn Garden City, Herts.



Figs. 15 and 16. Details of the Jensen moulded boot lid. (Left) Stiffening at the hinge attachment points. (Right) Method of strengthening at the lock

stiffening members are incorporated in the mouldings. In the body itself the stiffening members are out of sight and can be seen only in the front, hinged portion when it is in the open position. The incorporation of metal or wood stiffeners at points of maximum stress concentration offers number of advantages, especially in the development stages of a body. As moulding techniques become more advanced, however, it will be possible to eliminate metal and wood and to embody integral stiffening during the laying-up process.

An excellent method of producing light, stiff panels is the use of double-skinned which has been developed by the aircraft industry for the manufacture of radomes. This method is used in certain parts of the ultra-light experimental saloon body, previously mentioned. In principle this form of construction consists of two comparatively thin panels of laminate bonded to a core of low-density material which serves as a filler. A number of materials of low density have been found suitable, including Ozonote,* which is a proprietary form of foamed-rubber sheet, and Dufaylite,† an expanded phenolic-resin impregnated paper honeycomb. More recently an expanded aluminium-alloy foil honeycomb has been developed in the aircraft industry for the construction of floors and similar structures where light weight combined with stiffness is of paramount importance.

Another and interesting method of increasing the rigidity of double-skinned structures is the use of a liquid foam-filling, for which a number of materials have been developed. This form of construction is attractive owing to the simplicity of the process and because of the exceptionally low-density of the filler material which is prepared in liquid form and can, therefore, be used to fill a cavity of any shape. Of the foaming resins developed in this country, the Sebalkyd‡ compounds have been found suitable for use in structures of glass/polyester. The Sebalkyd resin foam is produced by the reaction of isocyanates. Carbon-dioxide is given off during the reaction and is retained in multiple cells as the resin sets. The density range of the foam, which can be controlled to suit the particular application, varies from about $1\frac{1}{2}$ to 30 lb/ft^3 . The foaming reaction is exothermic in nature and considerable internal pressure is developed which, for certain shapes, necessitates the use of restraining tooling. For some applications the internal-pressure is advantageous and serves to hold the outer skins against the face of the tool and increases the surface adhesion of the core and the laminate. Although possessing inherent advantages for certain structures, the process is expensive and in consequence will possibly be confined to critical components and to stiffening areas in

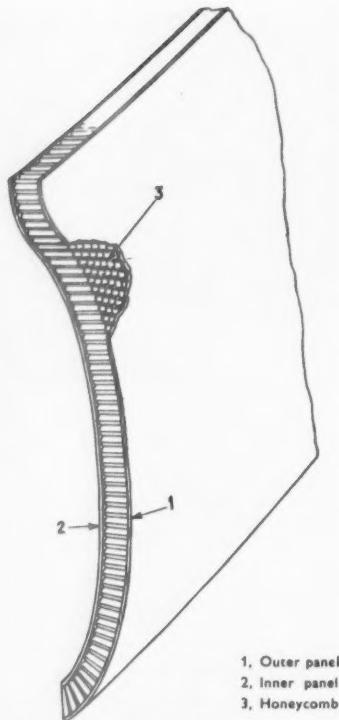


Fig. 17. Sectional view of a double-skinned door panel illustrating the use of a low-density honeycomb interlayer

high-performance, ultra-light body-work.

Attachment difficulties

One of the major problems in designing structures in glass-fibre laminate occurs where it is necessary to transmit load from a laminate into structures such as doors and into the chassis itself due to differing extensions when under load of the metal and the laminate. Much can be done to eliminate this difficulty at the design stage and recently adhesives have been developed for bonding metals to many of the newer laminated-plastics. In practice a number of methods have been evolved for joining stiffeners and similar parts. Broadly, the strength of the bond depends upon the absence, or at least the minimization, of flexing at the joint which may cause delamination of the plies. Where possible it is advantageous to cover the ends of the laminate with one or more plies of cloth, as shown in Fig. 19.

Where it is necessary to bolt laminates to traditional structures care should be exercised in the selection of the washer diameter to give the maximum bearing area possible upon the laminate, and consideration must be given to the edge-distance of all holes. The minimum edge-distance of holes should be at least twice the diameter of the bolt measured from the centre-line of the bolt to the edge of the panel. In addition, an increase in thickness is desirable at attachment points because of the low ductility of the glass-fibre reinforcement and lack

of relief at areas of stress concentration.

Secondary bonding operations are facilitated and the quality and load-bearing characteristics of the joint are materially increased by the incorporation in the final lay-up of a pull-layer, or extra ply of glass-fabric, which can be torn off immediately prior to the attachment of the stiffener or attachment. In this way, a uniformly roughened surface is presented which is entirely free of grease or fatty contamination which would reduce the efficiency of the bond. This technique eliminates sanding and overcomes the difficulty of producing a roughened surface in confined spaces and on the inner face of acutely curved panels.

Moulds

Both male, female and matched moulds can be used for moulding glass-fibre laminates. As already mentioned, male moulds are usually confined to the production of one-off and prototype work. Single moulds are the simplest type and can be made from a model of plaster, wood or metal. The mould can be either male or female, depending upon which surface of the work the finish is required. For the production of a car body the inside of the moulding is not important and in consequence a female mould which gives a good finish on the outside is used. The material of the mould has very little bearing upon the finished moulding and any of the materials mentioned can be used providing the moulding face is coated liberally with a mould-release agent before laminating is commenced. This operation is all-important because the finish obtained on the surface of the mould is reproduced on the outside of the body. It will be appreciated that careful preparation of the mould surface can materially reduce the cost of finishing each body produced—a time-absorbing operation and one requiring the services of skilled operators.

Laying-up

When the surface of the mould has been prepared it is usual to apply, either with a brush or spray-gun, one or more coats of high accelerator-content resin in order to give the body a hard, smooth surface and to eliminate air-bubbles and pin-holes. The layers of cloth or mat are laid in the mould when the last coat of resin has begun to gel or, at least, within two or three hours of its setting. If a longer period is allowed, the adhesion between the surfacing coats and the laminate may be reduced. Impregnation can be carried out with a brush or with a spray gun as each layer of reinforcement is placed in position. As the ultimate strength of the laminate is dependent largely upon its homogeneity, air-bubbles and voids should be eliminated, as far as possible, by squeezing, either by hand or with a roller. When using a roller it is usual, to avoid pick-up of the laminate, to cover the surface with a sheet of cellophane or to sprinkle the surface liberally with

*Expanded Rubber Co. Ltd., Mitcham Road, Croydon, Surrey.

†Dufay Ltd., 14/16, Cockspur Street, London, S.W.1.

‡Scott Bader and Co. Ltd., Wollaston, Wellington, Northamptonshire.

finely divided chalk. Glass-fibre laminates have good stability properties, but the best results are obtained from balanced laminates in which the outer and inner layers consist of the same type and number of plies of reinforcement.

Vacuum-bag moulding

The rubber vacuum-bag method of moulding previously described, can be used for moulding glass-fibre parts and produces an excellent and homogeneous laminate. Moulds for use with the vacuum process can be either male or female and can be made of wood, metal, plaster or glass-fibre laminate. To accelerate the curing-time, the moulds may be heated internally by steam pipes or externally by means of infra-red lamps. The reinforcement can be impregnated before or after it has been laid up but when using chopped strand mat, it is usually more convenient to lay the material on the mould before applying the resin.

To protect the vacuum bag from the resin and to prevent sticking, a sheet of cellophane or polyvinyl acetate is interposed between the surface of the bag and the moulding. This sheet has the advantage of providing a comparatively smooth surface on the inside or the outside of the moulding as the case may be.

The vacuum-bag method of moulding, although somewhat more complicated than the no-pressure method, permits work to be carried out more quickly. This is due to the fact that the application of pressure ensures complete impregnation of the fibre without an interval for soaking.

Pre-forming

A further method of producing glass-fibre laminates is by pre-forming. This process, which has been developed primarily for the quantity production of comparatively small articles, consists of scattering short filaments of glass on

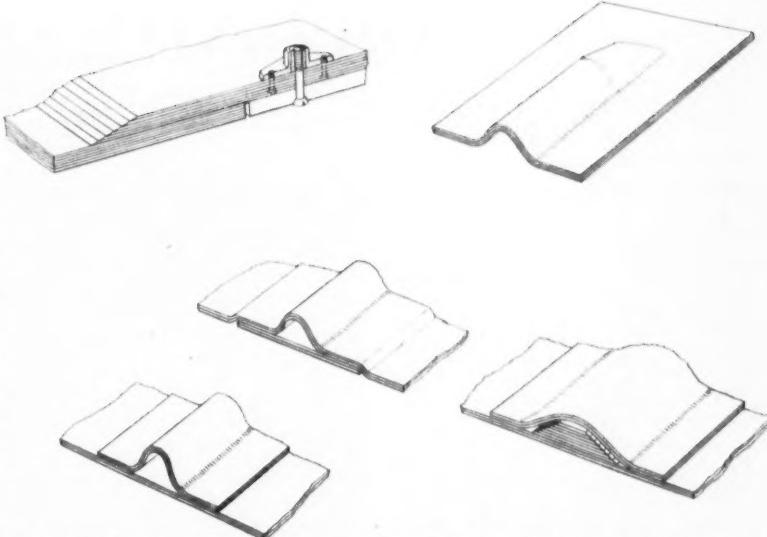


Fig. 18. Various methods of incorporating stiffeners and attaching laminates to traditional structures

to a fine-wire grille which corresponds in contour to the shape of the part to be produced. The underside of the grille is open to a large capacity air-pump which produces a stream of air through the grille sufficient to hold the filaments in position. While the filaments are being deposited upon the grille, a resinous binder is sprayed onto the material to hold the pre-form together and to permit it to be lifted off the grille when the desired thickness of mat has been built-up.

For moulding, the pre-form is placed in matched tools and impregnated with a hot-setting resin. The mould is then closed and subsequently the moulding is cured at a temperature of between 120 and 130 deg C.

Conclusions

In assessing the suitability of low-pressure laminates for automobile

bodywork, it would appear that as substitutes for traditional materials they offer outstanding advantages in weight-saving and in reducing body-maintenance costs. For short-run production or specialized work, the low tooling costs involved show to advantage, but for quantity production the inherent disadvantages are the comparatively lengthy laying-up process, the time required for curing and the difficulty of ensuring a consistently good surface finish without hand work. However, as more experience is gained, new and better moulding methods will, no doubt, be evolved to overcome these difficulties and to permit production in quantity. Moreover, large-scale production of the resins and other materials of construction may, conceivably, also lead to a reduction in their cost.

Laboratory Oven

An easily transportable, low-temperature oven intended for laboratory work has recently been introduced by The General Electric Co. Ltd. It incorporates all the features required to permit checking and controlling movement of components during tests involving long periods of heat-treatment.

The oven is of standard double-case construction with ample heat insulation, and has a full-length door at the front. Forced air circulation is provided by a centrifugal fan mounted in the roof. Sheathed-wire elements are mounted on the side walls behind metal shields which protect the charge from direct radiation and at the same time form part of the air circulation system.

It has an internal capacity of 3 ft³ and is rated at 9 kW. Temperature is controlled by an expansion thermostat and the oven is provided with temperature indicator and recording instruments, door switch, pilot lamps, and thermo-couple connections. Maximum operating temperature is 350 deg C.

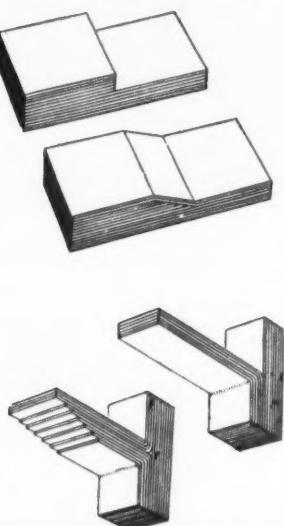


Fig. 19. Various methods of joining laminates and obviating delamination and ingress of moisture between the plies

CARBO-NITRIDING

A New Birlec Controlled-atmosphere Furnace for Light-case Work

TO an already wide range of heat-treatment equipment, Birlec Ltd., Birmingham, have now introduced a controlled-atmosphere mechanized batch furnace for carbo-nitriding light-case work. This new development is the outcome of a manufacturing agreement with the Dow Furnace Company, Detroit, Michigan, the first in the field in the U.S.A. with a furnace of this type. Combining the operating economies and advantages of large continuous furnaces with the flexibility of batch-type equipment, the furnace has become firmly established in the U.S.A. where over fifty are already in service. Leading American automobile manufacturers, in particular, have put down a number of installations.

Industry has long recognized the need for a versatile, controlled-atmosphere furnace capable of processing light-case work. Whilst suitable for deep-case work, the normal pit-type furnace has lacked the ability to control light-case depths and could not equal the surface finish obtained in the salt bath. This has meant that liquid cyaniding, with its high cost for labour, salt, maintenance and cleaning, has hitherto provided the only flexible means of producing a satisfactory light-case. A prototype furnace built for demonstration work at the Company's factory in Tyburn Road, Birmingham, has for some time now been producing a consistently high standard of case work on a wide variety of components.

Results obtained

The case produced by carbo-nitriding is similar to that obtained from the cyaniding process. Carbon and nitrogen from the enriching gases, butane and anhydrous ammonia, are absorbed at the steel surface and diffuse inwards to produce the case. The process is applicable to any steels which are at present cyanided, mild steel and carburizing steels in general as well as medium-carbon and low-alloy steels to which it is desired to impart a high surface hardness.

The temperatures used in gas carburizing are appreciably higher than those used for carbo-nitriding although the times taken to produce the same case depth are generally similar. In this respect, carbo-nitriding is comparable with salt-bath cyaniding. For example, to produce a case depth of 0.020 in by carbo-nitriding or cyaniding at 850 deg C, 2.25 hours at this temperature are necessary while 2.0 hours at 930 deg C are required to produce a similar depth of case by carburizing. The advantages of the carbo-nitriding process are that by using lower temperatures distortion of the components is greatly reduced and the many objectionable features

associated with salt-bath cyaniding, as mentioned earlier, are avoided.

Types of components already treated successfully in the demonstration furnace include mild steel wheel nuts, bicycle hub cones and chain wheels, as well as low-alloy gears, pinions and shafts. The resultant surface hardness has been generally between 800-850 D.P.N. on suitable steels.

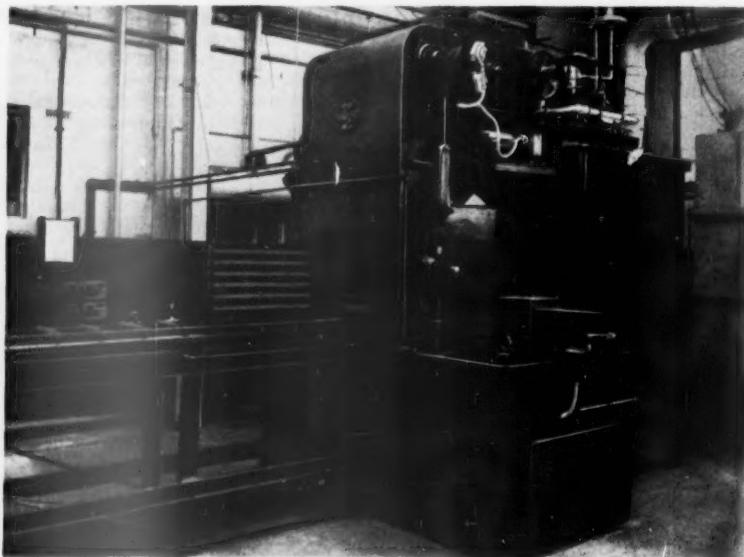
This new Birlec-Dow furnace is of the horizontal batch type, heated by vertical gas-fired radiant tubes. These operate, together with a refractory baffle, in conjunction with a powerful circulating fan placed in the roof of the chamber. The furnace is designed to ensure an unusually high uniformity of heating and case penetration on densely packed loads, coupled with an equal consistency of quenching, which is carried out without exposure of the charge to air. Complete freedom from scale and decarburizing is ensured, of course, by this controlled-atmosphere system of quenching.

atmosphere—to which ammonia and hydrocarbon are added for carbo-nitriding—which is fed directly into the furnace at the desired rate.

Another special feature of the furnace is in the provision of a high degree of thermal storage in the heating chamber by the use of baffle walls of refractory material placed between the radiant tubes and the charge. These walls serve not only to direct the high flow of atmosphere circulated by the fan through what may be a relatively densely packed charge, but also act as "heat capacitors" when a new charge enters the furnace.

Heat-capacitor effect

When a fresh load of work is put into a hot furnace there is a very rapid transfer of heat from the baffle walls to the circulating gases, which augments that given off by the radiant tubes. By the time the work in the furnace has reached its critical temperature that process is reversed, the walls by then

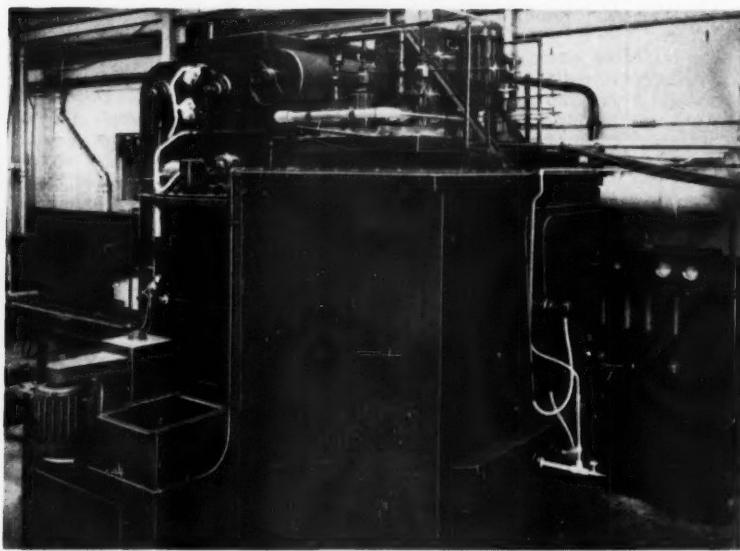


On the side of the vestibule chamber are power drives for vestibule and furnace doors. In the foreground is the quench tank with a motor-driven oil impeller. A charge container is shown on the loading conveyor

Self-contained generator

An important innovation is the incorporation of catalytic generators of endothermic type within the radiant tubes, which obviate the need for the more usual separate generator. This feature also enables the furnace to be used for clean-hardening medium steels in addition to carbo-nitriding and gas-carburizing. Mounted inside the U-shaped radiant tubes, these self-contained generators convert an air-town's gas mixture into the proper

are acting as heat absorbers. The walls are, therefore, able to store a considerable amount of heat produced by the radiant tubes, where temperature is maintained at a higher level by the action of the automatic control mechanism. The time required for the furnace to regain temperature after insertion of a new load is thus reduced. Through this heat capacitor effect the gradient in temperature through the load, as it approaches control temperature, is substantially less than that



Shown on the roof of the furnace are the motor drive for the circulating fan and the ends of two of the radiant tubes projecting above the sand seal

obtained when a simple radiation heating system is employed.

The rated input of the furnace is such as to heat 500 lb gross per hour from room temperature to 815 deg C with the furnace at control temperature when the load is introduced. The actual output of case-hardened work varies, of course, with the net load obtainable, the temperature and the required depth of case, but loads up to 600 lb can be processed, and outputs are generally in the range of 100-400 lb per hour. If required, a larger capacity model with a chamber and elevator designed for holding two containers arranged side-by-side can be supplied.

Integral quench tank

The front of the furnace is sealed by an enclosed vestibule which is situated immediately above the integral oil-quench tank. In this quench tank a motor-driven impeller is employed

not merely to agitate the oil but to direct it at a high-rate of flow right through the charge immediately this is lowered into the tank, thus ensuring uniformity of quenching to full hardness. The quench oil is maintained at a suitable temperature by finned water-circulating pipes housed within the quenching tank.

Inside the vestibule chamber is an elevator on which the charge is lowered directly into the quenching tank. The Birlec demonstration furnace has been provided with a two-tier elevator to enable a second charge to be held in the vestibule ready for placing in the furnace while the previous charge on the lower tier is immersed in the quench tank. The elevator has roller platforms serving, in effect, as an extension of the outside loading conveyor and of the rollers forming the base of the furnace chamber. It is supported on chains and is provided with an electric

motor drive. After immersion in the quench, the elevator is raised and the charge may then be withdrawn through the vestibule door opening.

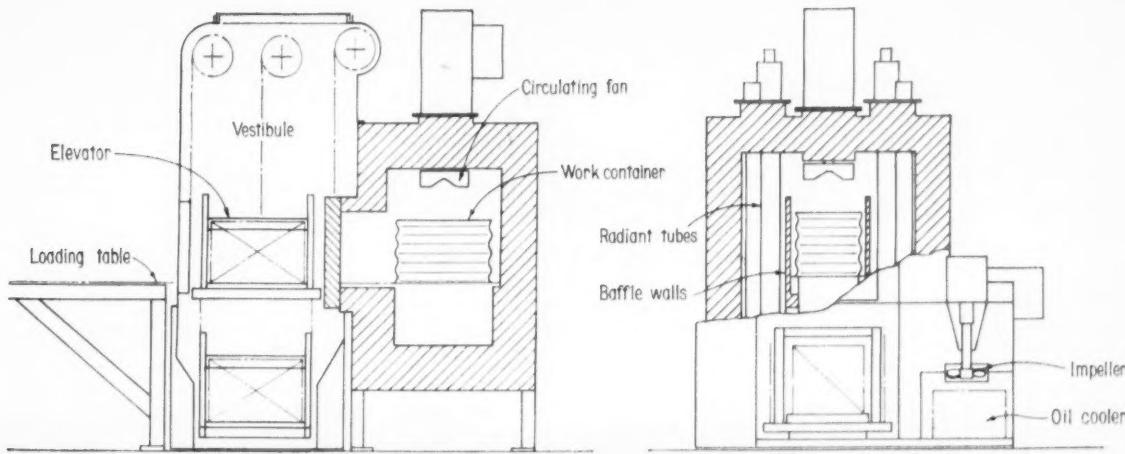
Construction

Occupying a space of approximately 9 ft 6 in by 9 ft, the demonstration furnace has an overall height of 10 ft 9 in; for removal of the radiant tubes a total head room of 15 ft is required. A mild steel casing is used for both the furnace and vestibule, the joints of which are welded gastight. The furnace walls are generously insulated to ensure a minimum of heat losses. Located between these walls and the heat capacitors are the four radiant tubes which are sealed at the points of entry through the furnace roof.

Also mounted in the roof of the furnace is the high-capacity circulating fan, the shaft of which is specially cooled. The furnace chamber has 1 ft 8 in of usable height above the nickel-chromium rollers and rails on which the load is supported and is arranged to take containers approximately 2 ft 5 $\frac{1}{2}$ in long and 1 ft 7 $\frac{1}{2}$ in wide. These containers have grid-type bottoms, to facilitate thorough circulation of the processing atmospheres and quenching mediums through the charge.

The front of the furnace, leading into the vestibule chamber, is sealed by an insulated door raised by a motorized chain drive. To give head room for the upper and lower elevator frames, the gas-tight vestibule projects above the furnace and has mounted on the sides driving motors and controls for the elevator and the furnace door lifting chains, and also the pneumatic cylinder for raising the vestibule door. The necessary power for operating this cylinder is drawn from the factory air lines. The vestibule door is provided with a small opening, having a sliding cover, to enable a hook to be inserted for sliding the work container in and out of the furnace. This operation may be performed by mechanical means, particularly on larger furnaces.

The height from floor level to the vestibule door is 40 in and the loading



General arrangement of the Birlec-Dow carbo-nitriding furnace

conveyor can be arranged parallel to or across the front of the vestibule or adapted in other ways to meet customers' own layout requirements. Extending below and on both sides of the vestibule chamber, the quench tank is provided with baffle plates to direct the flow of oil generated by the motor-driven impeller through the load when this is lowered into the tank. The layout of the furnace is such as to call for a minimum of skilled attention and it incorporates safety devices for shutting down in the event of power or gas failure.

Method of operation

Operation of the Birlec-Dow furnace follows well-established procedure. Air is kept out of the furnace by maintaining a positive pressure of endothermic atmosphere in the work chamber, and regulation of the hydrocarbon-ammonia addition is such that only sufficient carbon or nitrogen is provided for the process requirements. There is a prescribed cycle for starting, operating, and shutting down, and the furnace must be properly "conditioned" after a shut down and "burned out" at definite intervals to remove excess

carbon deposits from the furnace structure.

The use of an elevator in the vestibule chamber not only offers the advantage of enabling quenching to be carried out within the controlled atmosphere of the furnace, but also considerably reduces non-productive time. A continuous cycle of processing can be maintained by loading a work container and bringing this to the vestibule door during the time that a load is being processed in the furnace chamber. Before this is admitted to the vestibule chamber the elevator is brought to the down position by depressing the "elevator down" switch, which brings the upper platform in line with the vestibule door. The operator then admits air to the pneumatic cylinder that raises the vestibule door, and pushes the new charge waiting outside the vestibule on to the upper elevator platform. After the door is closed, air admitted to the vestibule during the operation is allowed to purge. The elevator is then raised to bring the lower platform in line with the furnace door in readiness to receive the charge being processed in the furnace chamber. When this charge is

ready for quenching, the furnace door is raised and the container is withdrawn on to the elevator by a hook inserted through the small slide-covered port in the vestibule door. The elevator is then lowered and the impeller motor switched on to agitate the quenching oil. As the elevator descends, lowering the treated charge into the oil, the new charge waiting on the upper elevator platform is brought into line with the furnace hearth and is pushed into the furnace chamber, after which the furnace door is closed. After approximately three minutes in the quench tank, the elevator is raised and the finished charge, after a sufficient interval for draining, is withdrawn from the vestibule. The loading cycle can then be repeated.

The experience gained in the U.S.A. and by Birlec with their demonstration furnace has not only confirmed the high efficiency of this type of furnace in practice, but also that striking economies are effected when compared with the cost of liquid cyaniding. The operating cost is claimed by the manufacturer to be only 40-50 per cent of that of salt bath treatment.

INSTITUTION OF MECHANICAL ENGINEERS

Forthcoming Meetings of the Automobile Division

The following meetings will be held during December:—

BIRMINGHAM CENTRE

Tuesday, 15th December, 6.45 p.m., in the James Watt Memorial Hall, York House, Great Charles Street. Paper: "The Application of Power Assistance to the Steering of Wheeled Vehicles," by F. H. Heacock, A.M.I.Mech.E., and H. Jeffery, A.M.I.Mech.E.

LUTON CENTRE

Wednesday, 16th December, 7.30 p.m., in the Town Hall Assembly Room, Luton. Paper: "The Manufacture and Properties of Automobile Suspension Springs," by C. J. Dadswell, Ph.D., B.Sc.(Eng.), M.I.Mech.E., J. E. Russell, M.A., and R. Fielding.

SCOTTISH CENTRE

Monday, 21st December, 7.30 p.m., in the Institution of Engineers and Ship-builders, 39, Elmbank Crescent, Glasgow. Paper: "The Small High-Speed Two-

Stroke Petrol Engine," by J. C. Morrison, Ph.D., B.Sc., M.I.Mech.E.

WESTERN CENTRE

Thursday, 10th December, 6.45 p.m., in the South Wales Engineers' Institute, Cardiff. Paper: "The Jaguar Engine," by W. M. Heynes, M.I.Mech.E.

The following meetings will be held during January:—

LONDON

Tuesday, 12th January, 5.30 p.m., at The Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1. Paper: "The Charging Processes of Internal Combustion Engines, with Special Reference to the Two-stroke Cycle," by Professor Dr. Hans List.

COVENTRY CENTRE

Tuesday, 5th January, 7.15 p.m. General Meeting in the Craven Arms Hotel, High Street. Paper: "Problems in the Design and Development of an

Economical Automobile Gearbox," by T. C. F. Stott, M.I.Mech.E.

DERBY CENTRE

Monday, 11th January, 7.15 p.m., in the Midland Hotel, Derby. Paper: "Continental Cars," by Laurence Pomeroy.

LUTON CENTRE

Monday, 11th January, 7.30 p.m. General Meeting in the Assembly Room, Luton Town Hall. Paper: "The Jaguar Engine," by W. M. Heynes, M.I.Mech.E.

NORTH-WESTERN CENTRE

Friday, 15th January, 7.15 p.m. General Meeting in Reynolds Hall, College of Technology, Manchester. Paper: "The Charging Processes of Internal Combustion Engines, with Special Reference to the Two-stroke Cycle," by Professor Dr. Hans List.

WESTERN CENTRE

Thursday, 7th January, 6.45 p.m. Informal Meeting.

FLUORESCENT TUBES

This advance has been made as a result of new techniques and improved manufacturing methods.

It is of interest to note that the luminous performance of the powders used to coat tubes of this type can be greatly modified by minute traces, in the order of a few parts in a million, of impurities. The chief contributions of

research to the improved tubes are the finding of the best formula for, and the best structure of, the fluorescent powder; the discovery of the best way to deposit the powder on the inner surface of the tube, and how to make it adhere permanently; and thirdly, the design of a cathode to produce the best life performance.

An announcement has recently been made by The General Electric Co. Ltd., to the effect that their fluorescent tubes will henceforward have greater reliability and efficiency. In particular, the Osram 5 ft, 80 watt Daylight and Warm White tubes, which are the ones generally used in industry, will give an increased light output of 12½ per cent.

THE MIDLAND RED S.14

Advanced Features of Design Incorporated in a Single-decker Service Bus of Integral Construction

ONE of the largest passenger transport organizations, the Birmingham and Midland Motor Omnibus Co. Ltd. constructs its own vehicles. It is, therefore, in a position to lay down its own specifications in their entirety, and the post-war additions to its large Midland Red fleet have established a reputation for the progressive quality of their designs.

The latest product from the Carlisle Road works in Birmingham, the prototype for 270 single-decker service buses, is in many respects revolutionary in character. Known as type S.14, it is at present undergoing stringent testing at the M.I.R.A. proving ground. It embodies such modern features as integral construction of body and chassis, underfloor engine, automatic transmission, independent front-wheel suspension, bonded rubber-metal suspension units at front and rear, disc brakes, a disc-type transmission brake, and a hypoid final drive. It weighs less than 5 tons unladen.

Some of these features have already been well proved. When vehicle production was recommenced soon after the end of the war the underfloor engine was introduced. It has been fitted to no fewer than 700 single-deckers and has in the aggregate covered approximately 150 million miles. This 8-litre engine is retained in the new S.14 design for two reasons; (a) the reduction in vehicle weight will reduce engine stresses and allow maintenance overhauls periods to be extended, whereas this would not be the case were a smaller engine to be used, and (b) the use of an existing engine, that is, one already in production, naturally makes for economy in manufacturing costs. It is a six-cylinder, direct-injection diesel of 113 mm bore and 133.3 mm stroke, developing 100 b.h.p. at 1,750 r.p.m. and a maximum torque of 350 lb-ft at 1,100 r.p.m.

Another post-war introduction was the all-steel body, built to B.M.M.O. design and specification by the larger body-building concerns specializing in this form of construction. The high performance of these vehicles, both from the operating and maintenance points of view, led to the production of two prototypes of monocoque or integral chassis-body construction. The first of these prototypes was built entirely in steel and has now completed 200,000 miles. The second was entirely of light alloy, with a stressed skin, and has covered 70,000 miles.

It is following the experience thus gained that the S.14 has been designed. It is of integral type, with a stressed skin, and is virtually of all-steel con-

struction, the only light alloy parts being the internal panels or stressed skin, the exterior panelling and the doors. The aims of the designers were the elimination of dead weight for a given strength factor, greater fuel economy, lower maintenance costs and increased passenger comfort.

Independent front suspension, of conventional coil spring and superimposed wishbone type, and the bonded rubber-metal rear suspension units have also been used on the two previous prototypes, so that considerable experience of these items has now been obtained.

A vehicle equipped with the Hobbs transmission has also been in regular service for several months. In its latest form, as fitted to the prototype, the Hobbs box has automatic change for the second, third and fourth gears in both directions, up and down. A mechanical overriding device, which allows the driver to make a quicker selection of his gears in case of necessity, is also now provided in the form of a small kick-down pedal.

Integral construction

The S.14 is built to the 30 ft by 8 ft overall dimensions and is provided with seats for 44 passengers. The various stresses of operation are distributed through the stressed-skin body sides and the structural members which form the underframe. Both

stressed inner skin, the underframe, the roof, and the front and rear ends. Each of these is built on a jig, and final assembly is made on an assembly jig, the front end framing then being added.

The underframe is designed to receive the engine, gear box and suspension without the position of the body pillars and windows having to be considered. It consists of a series of cross members of deep lattice-girder type, the maximum depth varying up to 10 in, which accommodate the front and rear suspension assemblies, and a number of channel-section pressings which are spaced to suit the mounting of the power unit and other components. In building up these members 2 in angle material of $\frac{1}{4}$ in thickness is used. The part of the framing that carries the rear suspension resembles a rectangular box of deep lattice girders. The members forming the front and rear of this box extend the full width of the vehicle and fit within two oppositely positioned crib-rail angles which extend the full length of the vehicle and are part of the side structures. Other deep lattice members brace the box fore and aft, being splayed out to join up with the two crib-rail angles.

Also of deep lattice-girder form is the framing for the mounting of the independent front-wheel suspension.

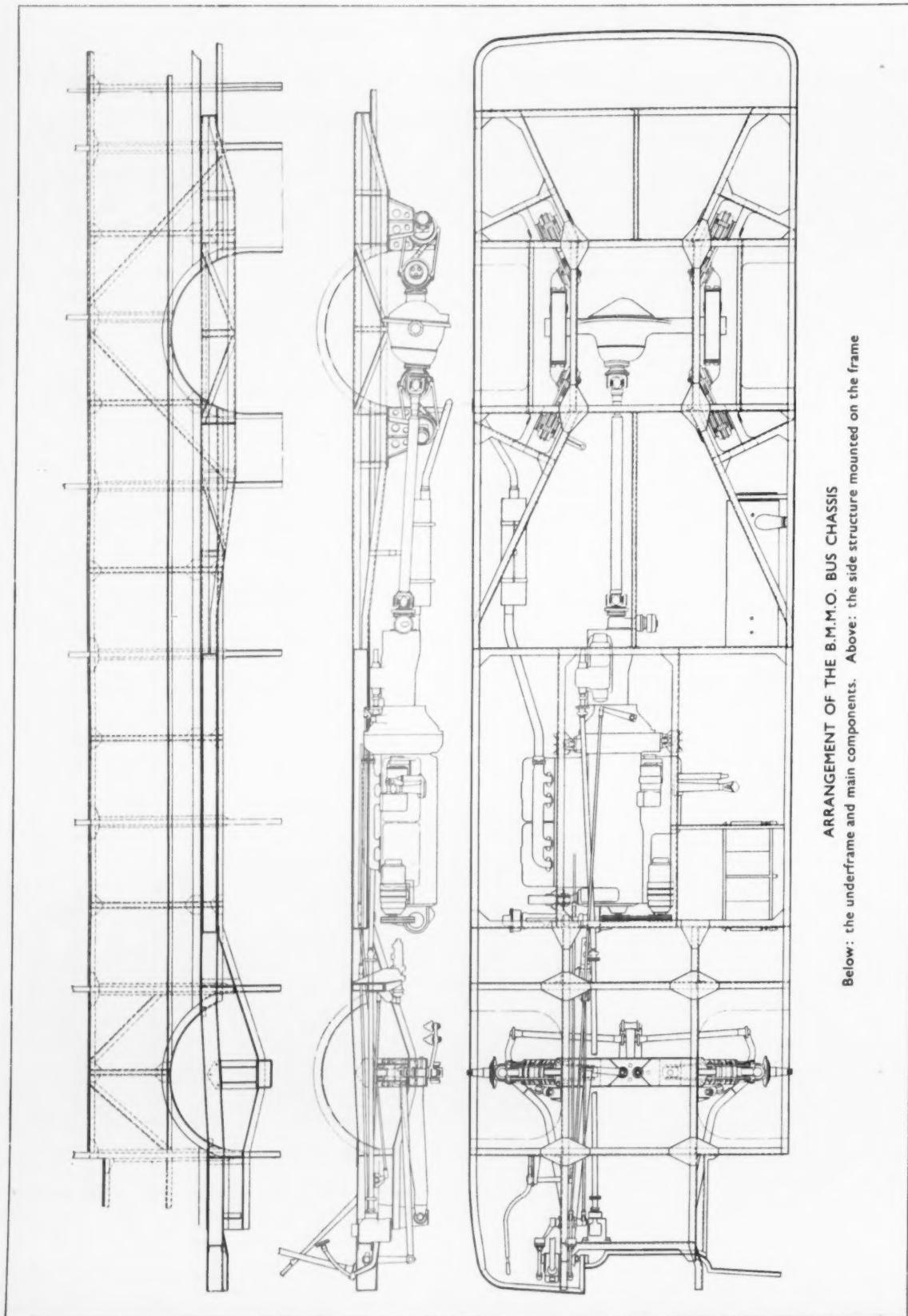


The Midland Red S.14 prototype

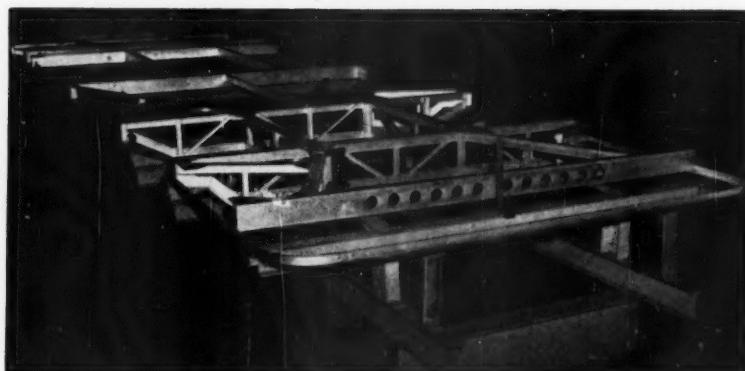
welding and riveting are employed in the construction, solid steel rivets being used in positions of stress while aluminum pop rivets are used to secure unstressed parts such as exterior paneling.

There are six main sub-structures, consisting of the two sides with their

It is reinforced with box-like brackets which support the suspension assemblies, and the lattice structures are bridged by a transverse member of box section. To the underside of this member are welded the brackets which form the mountings for the inner ends of the lower wishbones. At floor level



ARRANGEMENT OF THE B.M.M.O. BUS CHASSIS
Below: the underframe and main components. Above: the side structure mounted on the frame



The underframe structure on its assembly jig. View from the rear

the lattice structures are bridged by a member of inverted channel section.

The side framing is built up of pillars to which gusset-type brackets are welded to join up with the fence rail and cant rail. The jig for the assembly of the side framing is double-sided, the outer surfaces of the two sides as they take shape facing inwards towards one another at an angle.

The pillars are built up from $1\frac{1}{2}$ in square tube and $1\frac{1}{2}$ in top-hat section with $\frac{3}{4}$ in flanges, both of 18 gauge. At waist level the two sections are joined together by a short 18 gauge square tube dovetailed between the tube and top-hat sections so as to form a complete pillar, the halves being finally spot-welded together. This particular arrangement was adopted in order to secure maximum pillar strength at waist level with a maximum saving in weight, while the top-hat section facilitates the riveting of the stressed skin to the pillars.

For the fence rail, short lengths of inverted channel section are used, joining each pillar to its neighbours, but the cant rail is continuous and forms part of the roof structure. The two continuous crib-rail angle sections of 2 in material $\frac{1}{8}$ in thick are riveted to the flanges of the top-hat section of the pillar and are spaced $4\frac{1}{2}$ in apart so as to receive the extremities of the cross members of the underframe.

The light alloy stressed inner skin of 18 gauge is inserted between the inner faces of the pillars and waist-rail and the outer faces of the two crib-rail angles. Stump-type pillars of channel section are positioned centrally between each pair of main pillars and join the fence rail and the crib rails, to which they are welded and riveted, small gusset plates being used at the joints. The stump pillars form the joint line for the panels of the light alloy inner skin and also provide for the fitting of anti-drumming material for the outer panels, the joint lines of which are on the centres of the main pillars.

The lower crib-rail angle is continued over the wheel arch and is reinforced by two diagonal bracing members joining the stump pillar to the main pillar and to the wheel-arch

angle. The structure at this point is completed by the solid riveting of the 16-gauge light alloy wheel boxes to the wheel-arch angle and the underframe, and by solid riveting the main side-structure members with steel rivets and the stressed skin with light alloy solid rivets.

Top-hat section of 16 gauge is used for the cross members and longitudinal members of the roof. The cant rails are of 18-gauge channel section and, with the cross and longitudinal members, are built up on a jig prior to the final assembly, when they are solid riveted and welded to the gusset brackets on the tops of the main pillars. Finally, the exterior and interior lining panels are pop-riveted in place after the whole vehicle structure has been assembled.

There is no separate driver's cab, the driver using the front near-side entrance door. A full-depth partition is provided behind the driver's seat and is secured to the adjacent off-side pillar. On the central-gangway side the partition turns forward slightly and is joined to the front end structure by a shallow partition over which the driver steps to reach his seat. The entrance door is of gliding type and is operated electrically by the driver through switches controlling a C.A.V. electric door

motor with G. D. Peters' chain-drive gear.

Side windows are the Hallam, Sleigh and Cheston "Famco" type with double sliders, each window assembly being encased in its pan with a continuous glazing rubber. Windows are in $\frac{1}{4}$ in glass and the front screens are of $\frac{1}{8}$ in safety glass, that in front of the driver being raked in order to avoid reflections.

Seats are the B.M.M.O. light-weight type developed in conjunction with Accles & Pollock and weighing only 25 lb when trimmed. Heating is by a Clayton Dewandre C.H.V. recirculatory heater positioned beneath a seat at the mid-length of the vehicle. A Clayton Dewandre S.8 demister supplies four air-distribution slots in the front panelling. The 100 amp-hour batteries, master switch, control board and battery-boost unit are mounted on the near side immediately to the rear of the entrance, a hinged flap giving ready access to them. The floor is of $\frac{1}{4}$ in plywood, in two portions, with a butt joint on the vehicle centre line. It is supported by top-hat section members forming part of the underframe, has a P.V.C. covering of light weight, and floor treads in the gangway.

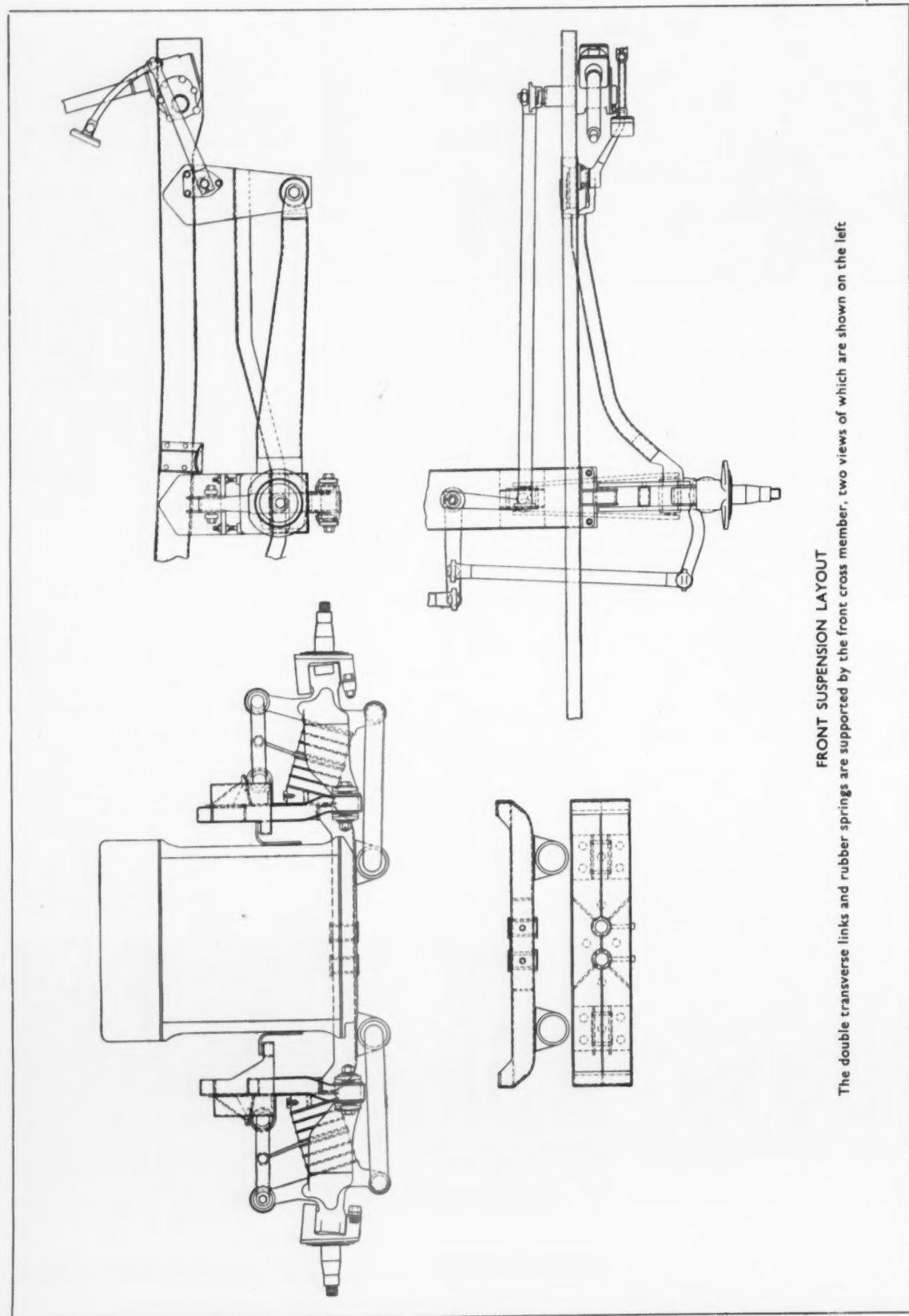
Front suspension

Front suspension is similar to the I.F.S. employing coil springs, as already used on a number of vehicles in service, except for the use of bonded rubber-metal suspension units developed in conjunction with Metalastik. The rubber is in shear and in compression, and the units are similar to those which have long been utilized in railway rolling stock.

Each unit consists of three layers of rubber bonded to metal plates, the end plates having bolt holes for their attachment. Two such units are attached to a centre plate, the upper end of which is hinged to the upper wishbone in order to resist any tendency of the spring to buckle. The other end plates are bolted to the front-wheel swivel standard and to a wedge-type bracket secured to the box-section bracket on



Both side structures in position on the underframe



FRONT SUSPENSION LAYOUT
The double transverse links and rubber springs are supported by the front cross member, two views of which are shown on the left

the underframe structure. Under load the spring is positioned with its axis at approximately 16 degrees to the horizontal. Provision is made for adjusting the height of the suspension in the event of any rubber creep, although it is anticipated that this will be negligible.

Superimposed wishbone links connect the wheel swivel standards to the underframe structure, and a box-section horizontal radius rod is bolted to the standard and extends forwards to a box-section bracket on the underframe; it thus locates the wheel and takes brake torque-reaction stresses. The length of the radius rod is considerable in comparison with the vertical displacement of the wheel, and in consequence the alteration in castor angle is small and has not proved to have any noticeable effect on the behaviour of the vehicle on the road.

Rubber bushes are used for the forward anchorage points of the radius rods and for the four pivot points of the wishbones. Metalastik ultra-duty bushes being used for the outer ends of the lower wishbones and spherical-type bushes at the other points.

From the foregoing description of the layout of the independent front suspension, the general manner in which the bonded rubber spring is loaded will be clear. Part of the weight is supported by the vertical component of the shear force in the rubber and part by the vertical component of the compression force. If the top and bottom transverse links are horizontal, as they are intended to be under the normal laden weight, then the vertical reaction at the hub is as follows:—

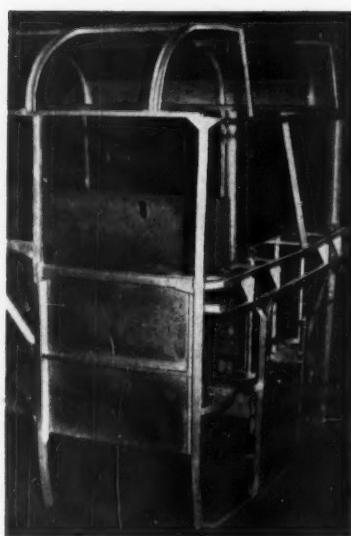
$$P = S \cos^2 a + C \sin^2 a$$

where P is the vertical reaction, S is the shear force in the rubber, C is the compression force in the rubber and "a" is the angle of the bonded surfaces to the vertical.

In the actual case of the Midland Red bus the angle "a" has a tangent of 0.3, so that the formula can be written

$$P = \frac{1}{1.09} S + \frac{0.09}{1.09} C$$

but no fixed rule can be given for the



The front-end structure is a separate sub-assembly

optimum angle or for the correct ratio of S and C . The design was worked out so that the ratio of the compression deflection to the shear deflection of the rubber is 0.3, that is, $\tan a$, but a different ratio of deflections could have been used. The compression and shear do not have to be removed in equal proportions when the abutment of the spring on the chassis is moved vertically upwards.

The non-linearity is due only in a very small measure to the stiffness characteristic of the spring, which for practical purposes can be assumed to obey Hooke's law. It is due almost entirely to the swinging of the transverse links. The effect is the same whether the long trailing arm is used or a corresponding leading arm or a double wishbone construction. The load supported in the attitude in which the links are horizontal is the same as if the axle were constrained to move vertically, but the stiffness is not the same. The reason is that if there is

any displacement of the spring in either direction the links become inclined to the horizontal, and the tension in them has a component tending to restore them to the horizontal position. This is analogous to a pendulum effect in which the horizontal component of the force in the rubber replaces the gravitational force on the bob of the pendulum.

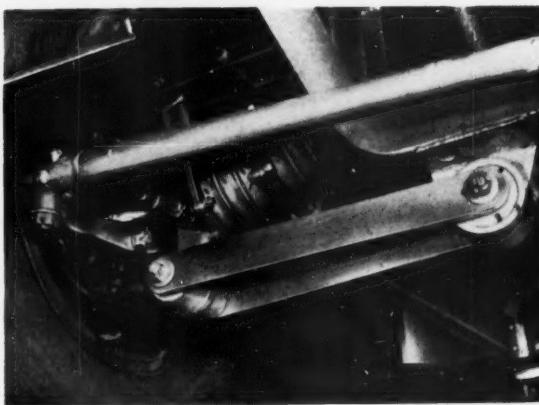
Any doubt about the added stiffness due to this cause can be removed by considering how the suspension would work if the bonded plates were absolutely vertical. In that case, if the links were horizontal, the pre-compression would not help in the load capacity but would add to the stiffness. In addition to this fundamental principle, the following detail points are of some importance:

1. The stiffening which results from the swinging of the links may appear at first sight to be a disadvantage because there is a higher periodicity for the same storage of strain energy in the spring material. The same argument can be used, of course, against most forms of non-linear spring and, indeed, the increased weight is one of the reasons why constant periodicity has achieved little popularity with users of steel springs.

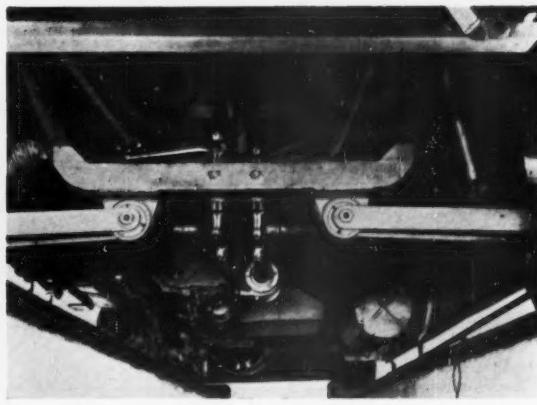
2. In the case of the rubber spring the disadvantage is not a real one. A certain amount of strain energy both in shear and in compression remains in the spring at zero supported rate, but it is a condition for maximum strain range in rubber that the value of the strain should keep all the time definitely on the same side of zero.

3. In the toggle link rear springing, the toggle effect does not increase the stiffness when the links are in line. This is because the bushes are concentric and the resistance is due entirely to torsional shear of the rubber. If the bushes were eccentric with the linkage in its aligned position, there would be a change in stiffness.

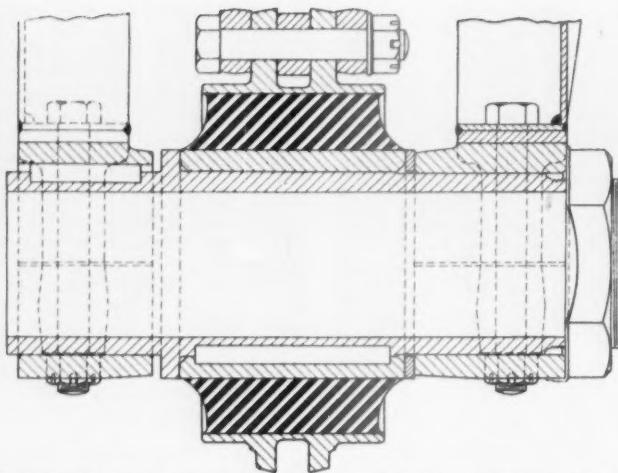
4. With the proportions of the top and bottom links actually used, the curve is a compromise between the straight line and the logarithmic constant periodicity. To achieve the latter,



Arrangement of wishbone links, rubber spring unit, and box-section radius rod. Underneath view from rear



Mounting of lower wishbones and the divided track rod of the steering layout. Underneath view from front



Diagrammatic section through a rear suspension unit mounted on the frame

a considerably shorter bottom link would be needed and the periodicity would be well above its present value, either light or at full load.

5. The compression stiffness of the spring is $17\frac{1}{2}$ times its shear stiffness and this ratio would be increased, of course, if there were more intermediate metal plates.

6. Due to the direction of the resultant force in the rubber spring there is a large continuous tension in the lower transverse link and normally very little force in the top link. It is considered a definite advantage with the difficult lower wishbone links to have the load always in the same direction, not reversing continually as it does with normal springing. As a tension member the bottom link can also be constructed fairly lightly.

7. The spring is described, of course, as loaded in compression and in shear, but in practice it is impossible to get shear without bending. The intermediate steady plate which connects to the middle of the top transverse link does not affect in any way the shear and compression movements but keeps the centre cross-section of the spring parallel to its built-in ends, thus eliminating the greater part of the

bending effect. The initial off-set of the springs is also aimed at reducing the bending, and it is under consideration to increase the off-set in a new or modified design by stepping the inner element of the spring upwards by $\frac{1}{4}$ in to 1 in relative to the outer. This can be done in the attachment to the intermediate plate, which can be made with dowels in place of bolts. The compression is so much greater than the shear that there is no danger of slipping or fretting.

8. If the off-set were chosen accurately there could be no bending moment on the steady plate in the mean position. It does not follow, however, that the steady plate could be omitted. If it were, the central plates would still rock through a large angle as the spring moved up and down.

9. The different characteristics for the very light bus and for the luxury coach to which this suspension is also being fitted are achieved by change in the rubber mix, but the difference in weights is not so large on the front axle as on the rear axle. Eventually it should be possible to reduce quite considerably the size of the rubber springs for lightweight buses.

10. Although the internal damping of the rubber is not sufficient to enable the bus to run without shock absorbers, it does seem that the size of the dampers can be reduced from that found necessary in conjunction with coil springs.

Rear suspension

For the rear suspension Metalastik units employing rubber in torsional shear are used, following their successful behaviour over nearly a quarter of a million vehicle miles. Four such units are employed at each end of the rear axle, two being in front of the axle and two behind it. The units of each pair are connected together by two toggle links joining their outer metal casings or sleeves, their inner metal bushes being secured respectively to the mountings on the underframe and on the axle casing. The pairs of units

are also set at an angle to the longitudinal axis of the vehicle, so that seen in plan they form a wide-angle vee. Accordingly they position the axle and tend to prevent rolling on corners.

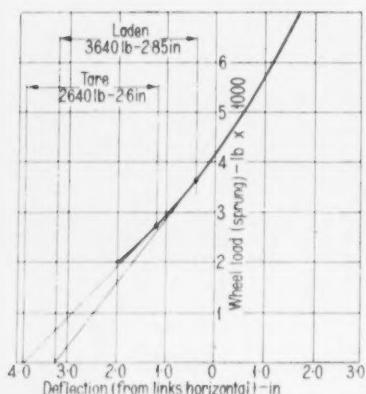
The four rubber units at each side lie with their centres in the same horizontal plane when the vehicle is unladen, and the load is carried entirely by these bushes with the rubber in torsional shear. With deflection there is, however, eccentricity of the inner sleeve relative to the outer sleeve, and the resistance introduced in the rubber by this eccentricity is in addition to that due to change in torsional deflection. The eccentricity causes increased stiffness as the deflection increases, and over the normal load-deflection range from unladen to laden the stiffness of the system is proportional to the load carried. The result is that the ride is uniform whether the vehicle is empty or full.

Further spring travel due to over-load or bump increases the stiffness rate more rapidly, while there is also progressive stiffening of the springing for the rebound position. The outer sleeve of each bush is provided with jaw-shaped extensions which accommodate the toggle links, and there are in addition diagonally placed turn-buckles which provide for adjustment and for the re-setting of the suspension due to any slight settling which may occur in the rubber after a period of service. Newton Bennett direct-acting hydraulic dampers control both front and rear suspension units.

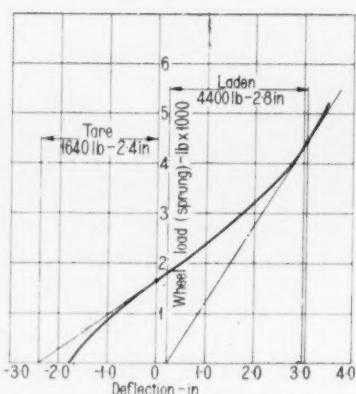
Disc brakes

The Girling disc brakes on the front wheels have six hydraulic cylinders and pistons applying the brake pads direct, three at each side of the disc, these being accommodated in a caliper member which is arranged with its mid-point approximately on the neutral axis of the wheel, so that the action of the brake shall be unaffected by any rocking of the wheel on its bearings due to necessary clearances or, in the course of time, to wear.

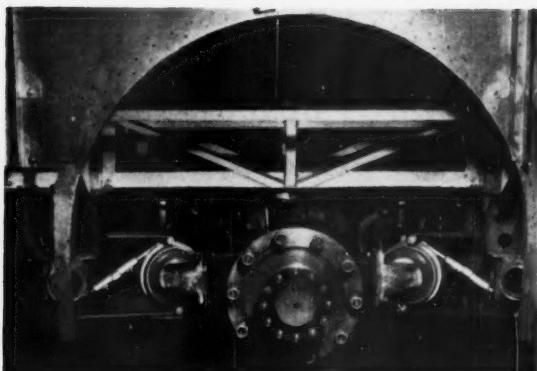
The rear disc brakes have four hydraulic cylinders to each side of the disc, and they operate the friction pads



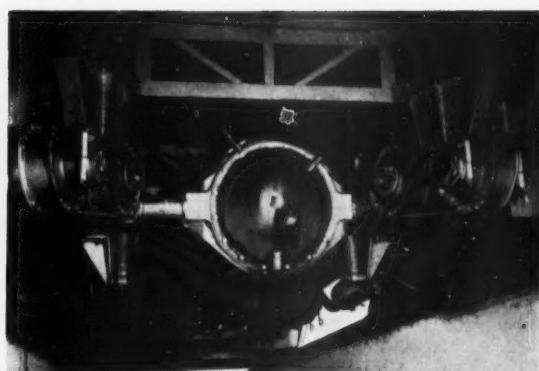
Load-deflection curve, front suspension



Load-deflection curve, rear suspension



Arrangement of rubber-metal rear suspension units, toggle links and turnbuckle-type adjusters



Mounting of the rear suspension units. View below the vehicle, looking forward

through rocking levers so that the hydraulic system is thus removed from the source of heat. The system incorporates the continuous-flow hydraulic servo, produced by Automotive Products, which is used on all the vehicles of the B.M.M.O. single-decker fleet.

Fitted to the transmission as an experiment is a manually-operated disc brake, for the designers consider that only on the transmission will a hand-brake provide the efficiency given by the footbrake. It is, therefore, desired to obtain data and experience for later reference in the event of transmission brakes being legalized in the future. The disc is mounted on the pinion shaft of the final drive and it has a single friction pad at each side of the disc operated through rocking levers and a Girling wedge-type expander.

Regarding the power unit, the engine in the prototype has a light alloy crankcase with a separate cast iron cylinder block, but this will be superseded by a combined crankcase and cylinder block in cast iron. Pistons are of toroidal-cavity type and are produced in silicon alloy. The big-end bearings are of lead-bronze, and the seven-bearing crankshaft is Tocco hardened and is carried in half-and-

half lead-bronze and white-metal bearings with steel main bearing caps. The cast camshaft is rigidly supported in seven bearings and has hardened bearing surfaces and cam profiles. It is chain driven from the crankshaft and a manually adjustable chain tensioner is provided.

Lubrication is arranged on the wet-sump system, with the oil pump mounted on the front main bearing cap and driven from a gear at the front end of the crankshaft. The oil sump is a one-piece casting with its rear half arranged as an oil reservoir with a capacity of 4½ gallons. Oil is drawn from the sump through a wire-gauze filter and passes through a close knife-edge type pressure filter to the main bearings by way of an oil gallery mounted on the outer faces of the bearing caps.

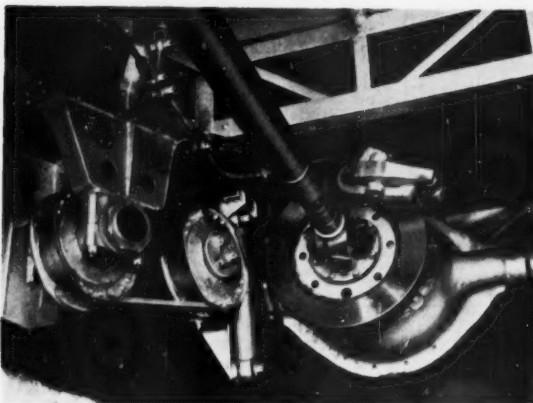
The fuel injection pump drive is through a small bevel gear box mounted in the front end of the engine, the drive being taken off an extension of the camshaft. The pump itself lies parallel to the axial centre line of the cylinders and points towards the off-side of the vehicle. The power unit is supported on two Metalastik conical rubber bushes at the rear end and by a single parallel-type bush at the front end.

Either the standard design of B.M.M.O. four-speed gearbox or the Hobbs automatic transmission can be employed and in both cases they are arranged for unit construction with the engine; the gearbox casings are of light alloy. If the standard gearbox is utilized a single dry-plate clutch is used.

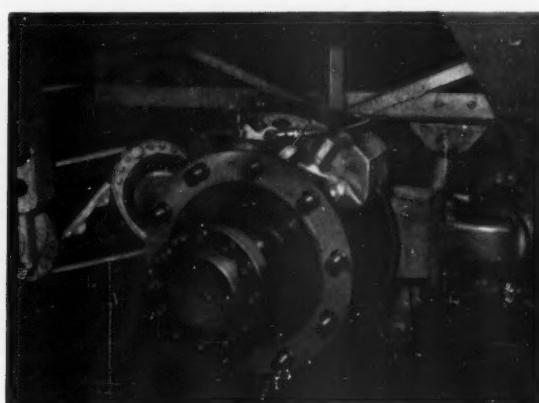
A hypoid bevel final drive is fitted, following successful experimental operation over some thousands of miles. The open propeller shaft is equipped with Hardy Spicer universal joints.

Steering is by a Marles double-cam unit and in order to obtain minimum turning circles to off-side and near-side the track-rod is divided. The inner ends of the two links are supported by swing levers mounted on vertical shafts carried in a bracket off the box-section cross member of the suspension. The upper end of the off-side vertical shaft carries a steering lever which is attached to the rear end of the drag link. The steering unit is arranged with the drop arm facing inwards towards the centre line of the vehicle.

Both front and rear wheels carry single 9.00 × 20 in tyres, following satisfactory service by single rear tyres on a number of Midland Red vehicles for a considerable period of time.



A disc brake on the pinion shaft is manually operated through a Girling wedge-type expander and rocking levers



The rear wheel disc brakes are hydraulically operated but the friction pads are actuated through rocking levers

A COMMON TOLERANCE SYSTEM

The "A.B.C. Proposals" Critically Examined

F. W. M. Lee, M.I.P.E.

AMERICA, Britain and Canada (A.B.C.) are endeavouring to establish a Common Tolerance System, known as the "A.B.C. Proposals," to ensure interchangeability of manufacture. For this purpose the British Standards Institution (B.S.I.) has submitted for consideration a conversion of the Continental I.S.A. System from metric to the inch equivalents. Such a proposal must satisfy certain essential requirements and in reviewing the problem it appears that there are four broad aspects which should be considered.

- (1) What is the fundamental basis of the I.S.A. System?
- (2) To what degree does the theoretical conception of the I.S.A. System satisfy practical requirements?
- (3) Will the conversion from millimetres to inches contribute to or detract from the I.S.A. System?
- (4) Is the conversion suitable for use as a Common Tolerance System?

It is not possible in the course of an article of limited length to give each of these questions the comprehensive investigation it merits, and the following remarks are confined to the salient features only.

Fundamental basis of the I.S.A. System

Reference to the B.S.I. publication B.S.164, Part 1: 1951, and to other sources indicates that the I.S.A. System is derived from:

- (1) Preferred numbers.
- (2) Existing Continental practice.
- (3) A geometric series.
- (4) An arithmetical progression arranged in a purely arbitrary fashion.
- (5) The following formula:
"The fundamental tolerances" are multiples of the fundamental tolerance unit '*i*' where $i = 0.001 \text{ in.} = 0.052 \times \sqrt[3]{D} + 0.001 \times D$ (*D* in inches)."

To the practical engineer the following might be more acceptable:

- (1) Preferred tolerances.
- (2) Based upon modern British and American practice.
- (3) In easily understood steps.
- (4) A formula in keeping with the mathematical capacity of the majority who will be using it.

By definition, a "system" is "a regular method or order" which cannot apply to the I.S.A. since the toler-

ance values have been collected from a number of unconnected sources and assembled as a table.

Dominating feature of the I.S.A. System

The tolerance steps from H5 to H6 onwards, as plotted in Fig. 1, show that the aforementioned cube root formula sets the general pattern from which it will be noted that the curve rises slowly at the commencement, increasing its slope reasonably for a short distance, then running away at an extremely steep angle to the end. The significance of this curve and the tolerance steps it gives will be referred to in the remarks concerning the "I.S.A. in Use."

Tolerances not calculated

It is evident from an inspection of Fig. 2, constructed upon the tolerance

the qualifying statement "the inch tolerance values have been obtained not from the I.S.A. tolerance formulae, but by direct conversion of the metric values."

It follows that a tolerance for any diameter not given in the tables could not be calculated and would, therefore, have to be decided by protracted international agreement, which is impractical.

Remaining features of the theoretical I.S.A. System

- (1) There are sixteen grades of manufacturing accuracy.
- (2) Twenty-one types of fit.
- (3) Particulars given for the manufacturing tolerance on the gauge ends themselves.
- (4) The amount the gauge may wear before withdrawal from service is stated.
- (5) Recommendations for fits are provided with examples.
- (6) A claim is made that if the grade of the hole and the shaft are confined to the same qualities of manufacture, as, for instance, H7 g6, the "feel" will be the same irrespective of the diameter.

The I.S.A. in use

It will be realized that the I.S.A. System, whilst partly based upon existing practice, is essentially a theoretical conception, and it is proposed to show how and why the original has been extensively modified in practice.

From B.S.1916, Part 1: 1953, pages 16 to 23, I.S.A. conversion, it will be noted that there are limits for holes from oversize to unilateral to bilateral to undersize consisting of 64 possible tolerances for a 1 in. diameter hole. In France and Holland, however, this has been reduced to the unilateral series H6, 7, 8 and 11. In this connection it can be said that the three tolerances H6, H7 and H8 are suitable for fits and H11 for clearance holes.

Similarly, from pages 24 to 31, there are 74 possible tolerances for an inch shaft as compared with the actual practical application by I.S.A. users of 7 degrees of precision characterized by the numbers 5, 6, 7, 8, 9, 10 and 11. The range, however, may be increased to cover exceptional conditions of service.

From the broadsheets issued by

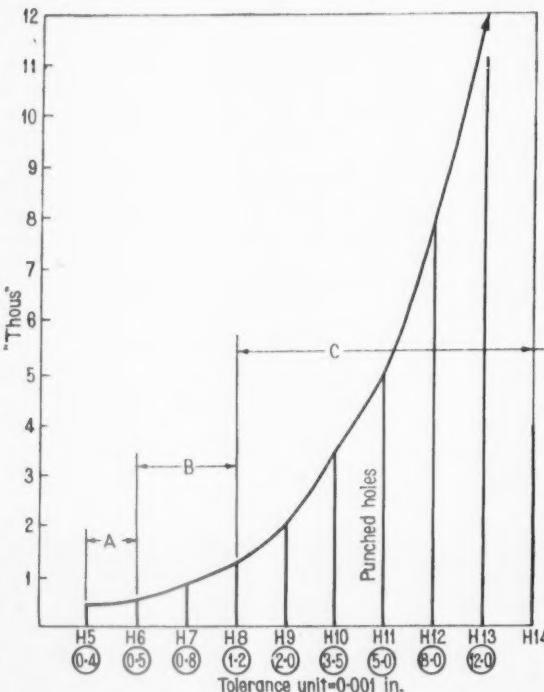


Fig. 1. Tolerance values for 1 in. diameter hole, unilateral "H" series B.S.1916, Part 1: 1953

proposals given in B.S.1916, Part 1: 1953, that the tolerances were not calculated, since calculation would ensure that the curves would not deviate at points A and B. That this was realized during the conversion from millimetres to inches is confirmed by

engineering firms in France and Holland it will be found that the unilateral system only is specified. It will, therefore, be realized that the original theoretical conception of the I.S.A. System has been drastically reduced in practice to virtually a three-hole system (Newall A, B and C). Investigation of nearly 10,000 limits has already shown this to be inadequate and will not satisfy the requirements of the whole of the engineering industry with the inevitable result that the existing difficulties of "special tolerances" will be perpetuated.

There must be a sound practical reason for this limitation of scope to arise and further investigation discloses it. As already mentioned, the fundamental basis of the I.S.A. System is a cube root law producing a tolerance step curve as shown in Fig. 1.

Inspection of this curve shows the slope to be so slow at the commencement that the maximum diameter of a 1 in. H6 hole is only one tenth of a "thou" larger than an H5 hole, which for practical purposes is useless and has been discarded. The slope then increases and provides suitable steps for the following three tolerance grades of H6, H7, H8, that is, 5 tenths, 8 tenths and 12 tenths tolerance for a 1 in diameter hole.

Subsequently the curve commences to rise more rapidly and the tolerances for H9 and H10 become too large to be considered suitable for customary fits. H11 is used as a rough check on drilled or punched holes. From H11 onwards to H16 the slope is so steep that the tolerances provided are meaningless, since the majority from H13 onwards are so large that they can be measured with a steel rule.

It will be clear that the fit tolerances of H6, H7, H8 have only been chosen because they happen to fall upon that part of the curve the slope of which is suitable for the provision of practical working tolerance steps and the remainder, which form the greatest percentage of the original conception, have been ignored. A tolerance system, if it is to be thoroughly comprehensive, must provide tolerances suitable for watches to warships, and the limited range of H6, H7 and H8 could not possibly be considered adequate to embrace this very wide field.

Having in mind the extremely complicated nature of the I.S.A. System (see B.S.1916, Part 1:1953, page 54, Appendix B and C) the question was asked on the Continent if it was found to be complicated in use. The answer was "No, after the general idea has been grasped." Since the I.S.A. System has, by practical application, resolved itself into a simple unilateral, three-hole system of limited coverage and use the reply is understandable.

Gauge manufacturing tolerances

In Britain, the gauge manufacturing tolerance is 10 per cent of the limit, but in the I.S.A. System this is increased to 33.3 per cent, which no doubt will please the gauge maker, but not the user of the gauge, for it will

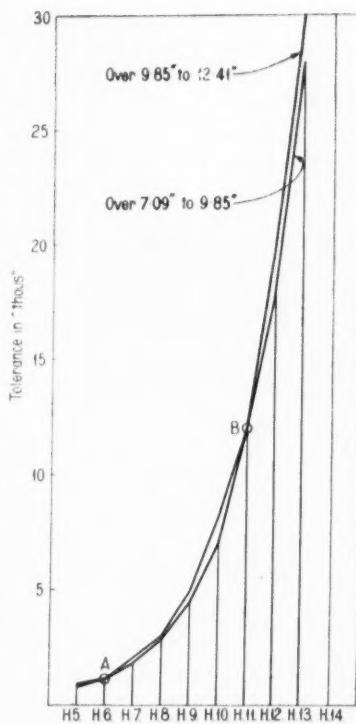


Fig. 2. Tolerance step curves

be found that when the "Go" end has been made to its largest permissible diameter and the "Not Go" to the smallest permissible diameter, the gauging system has robbed the shops of no less than half of the drawing tolerance. This is not only unreasonable, but also unrealistic.

Permissible gauge wear before withdrawal

The I.S.A. System specifies this amount in tables supplied, but whereas the British practice is 10 per cent of the limit, the I.S.A. System varies, and in one example it is 14 per cent and another 21 per cent. These percentages are excessive and inconsistent.

Summarizing the I.S.A. System in use it has been found that owing to the cube root formula providing unsuitable tolerance steps:

- (1) Practice has virtually reduced it to a unilateral, three-hole system with limited coverage.
- (2) Gauge manufacturing tolerances can rob the shops of 50 per cent of the drawing tolerance.
- (3) The amount the gauge is allowed to wear undersize is excessive by British standards.

B.S.I. Conversion—B.S.1916, Part 1: 1953

Perusal of this publication shows that tolerances are provided for oversize, unilateral, bilateral and undersize holes with the result that there are 64 tolerances available for a 1 in diameter hole. Shafts are also amply provided for, since in many diameters 74 tolerances are given.

Bearing in mind the practical operation of the three-hole I.S.A. System the reason for the foregoing is difficult to understand. No doubt the number of tables could be reduced, for it will be noted that overlapping occurs, as for instance A9 and H9. A9 tolerances are +10 "thou" and +11 "thou" for a 0.040 in diameter hole. The smallest size of the hole is therefore 0.050 in, an increase of size of 25 per cent. The same hole could be specified by a 0.050 in hole in H9 which would be 0.050 in +1.0/+0.0 "thou."

Conversion affects interchangeability

The difficulty of converting millimetres to inches is well known because the inch fractional sizes obtained are unwieldy and become more complicated in the process of correlating them to an existing tolerance table. In the I.S.A. System the diametrical change steps are simple, 1, 3, 6, 10 mm for instance, but when converted become 0.040, 0.119, 0.237, 0.394 in and rounding is resorted to giving 0.040, 0.120, 0.240, 0.400 in. Odd unfamiliar sizes do not simplify matters.

Similarly, the tolerance values themselves have also been rounded with the result that in one case the difference between the actual I.S.A. tolerance and the inch conversion is nearly "half a thou" (4.8 tenths). Again, through rounding of the diametrical change steps it will be found that an inch-dimensioned component would be made to a different set of tolerance values than its millimetre counterpart, because one would fall into one range of tolerances and the other into another.

Further, a British or American designer would not consider making a shaft 0.3937 in diameter (10 mm) where he would normally employ one of 0.375 in ($\frac{3}{8}$ in) diameter, since the decision has already been made by the availability of raw material sizes.

The possibility of interchangeability is still more remote when the following are taken into consideration:

- (1) Different units of length.
- (2) Different tolerances due to rounding.
- (3) Different raw material sizes.
- (4) Metric threads.
- (5) Metric collets, feed fingers, etc.

While the ideal of interchangeability between millimetres and inches is highly desirable, its practical attainment is impossible.

Summarizing briefly the foregoing and making reference to further points which require serious consideration it will be found that:

- (1) The cube root law of the I.S.A. has little connection with practical requirements.
- (2) The practical application of the theoretical I.S.A. System shows that the greatest proportion of it is obsolete.
- (3) Owing to the unsuitability of the tolerances the I.S.A. can be said to have resolved itself into a unilateral, three-hole system.
- (4) There are insufficient suitable tolerances to cover the whole of engineering requirements.

- (5) The B.S.I. conversion perpetuates tolerance values which have already been proved to be of no value in practice and are redundant.
- (6) A perusal of B.S.1916, Part 1: 1953, Appendix "B" and "C" shows it to be complicated, a fact which has been commented upon in all three A.B.C. countries.
- (7) The diametrical tolerance change steps in millimetres are easily assimilated, but when converted to odd unfamiliar fractions of an inch become unwieldy.
- (8) Having considered the fit, tables must be searched in order to find the appropriate hole and shaft with the desired tolerances.
- (9) The manufacturing tolerance for the gauge can rob the shops of 50 per cent of the drawing tolerance.
- (10) The wear allowance on gauges before withdrawal from service is excessive.
- (11) Hope of interchangeability with the Continent has been destroyed.
- (12) Any tolerance not shown cannot be calculated and settlement must rest upon protracted international agreement.
- (13) By providing tolerances for both unilateral and bilateral systems the number of tables is doubled, gauge stocks enlarged and complication increased, for which there is no sound practical justification when establishing a new tolerance system.
- (14) The contention that the I.S.A. System provides the same "feel" for any fit when the hole and shaft are made to the same qualities irrespective of diameter and the proportion of diameter to length cannot be sustained until the human element has been eliminated and "feel" determined and measured mechanically.
- (15) No tolerances are provided for horological or instrument trades.
- (16) The tolerances for undersize holes are mixed up with the table for bilateral holes. See K6, K7, K8, M6, M7, M8, B.S. 1916, Part 1: 1953, page 20.
- (17) The I.S.A. System is completely divorced from existing British and American practice. By its adoption an enormous quantity of existing gauging equipment would become obsolete. The cost of its introduction would be fantastic.
- It is the Author's opinion that a comprehensive and practical limit system should be so simple that it will neither tax nor defeat the ability of the draughtsman, the inspector, or the man in the shop and should be the servant and not the master of the user.

NEW THRUST BEARING

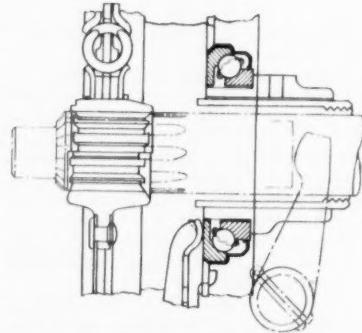
A Ball-type Bearing Designed for Clutch Withdrawal Mechanisms

CLUTCHES in modern motor vehicles have to operate under more and more exacting conditions as a result of increasing traffic congestion at home, and because of specific requirements of overseas markets. In consequence, the carbon block type of thrust bearing, frequently used in clutch withdrawal mechanisms, has sometimes been found to give an unduly limited life. The flat thrust-washer type ball bearing that is often used for this application is not entirely satisfactory, and trouble has been experienced as a result of ball spin. This spin takes place because the thrust is not great enough to prevent the balls from being flung outwards by centrifugal force and, as a result, true rotation of the balls on one axis cannot take place. Moreover, the grease tends to be flung clear of the cage and balls, and this condition is aggravated by the high temperatures caused by ball spin.

Ball bearings of the deep-groove type have also been used in clutches, but in some quarters they are not regarded as suitable for this application. The two-piece, ribbon type, pressed

cage employed in these bearings allows neither for slight inaccuracies in assembly in the clutch mechanism nor for any deviation from true thrust loading. Therefore, the track diameter of the path followed by the balls varies; and the acceleration and deceleration, caused by ball precession round the tracks, apply to the cage severe loads which sometimes cause it to fail.

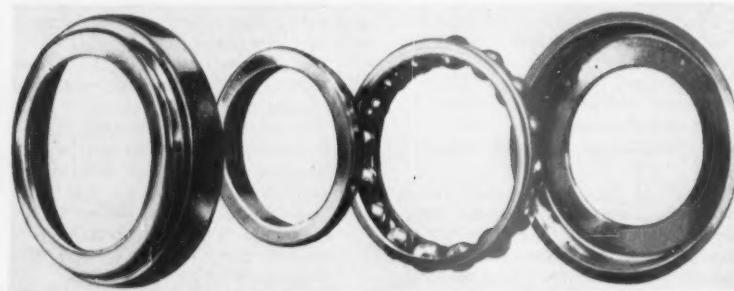
These considerations led the technical department of Pollard Bearings Ltd. to the conclusion that a bearing should be designed specifically for application to clutches. They decided to employ the angular-contact type of bearing, which is to a certain extent self-aligning. The self-aligning characteristic of this type of bearing arises partly because of its race form and partly because a large number of balls of relatively large diameter may be fitted within the limiting overall dimensions. Furthermore, a one-piece cage may be used, and this allows the balls a certain amount of circumferential freedom of motion. This freedom tends to prevent unduly high loading of the cage.



The new bearing in a Borg and Beck clutch

Developments have proceeded on these lines and a new range of clutch withdrawal bearings has now been introduced. These bearings are suited to pure thrust loading, and may be applied in conventional clutches as well as in automatically operated units. As can be seen from the illustration, the outer race has an end face of relatively large radial width and this forms an adequate bearing surface against which the clutch-operating levers may bear. The track form of both the inner and outer races is so designed that after the unit has been assembled, the races do not separate. Therefore, when the thrust load is released, the balls remain within the track, and operation is noiseless.

Pollard Bearings Ltd. state that tests so far carried out by independent motor manufacturers have shown that the life of this unit is more than fifteen times that of a standard clutch withdrawal bearing. So far, a failure has not been produced by these tests, after completion of which the bearings, when stripped, have been found to be well lubricated and fit for a much longer period of service.



A pressed steel shroud ring encloses the bearing assembly and not only retains the grease but also protects it from foreign matter

DEEP-HOLE BORING

*Development of a New Production Process for High-speed Boring:
Current German and Swedish Practice*

H. J. Pearson*

DEEP-HOLE drilling is generally regarded as a difficult process to control on a production basis since it is not possible to observe machining conditions at the point of cutting. This difficulty of producing a deep hole—irrespective of whether it is necessary to obtain a high degree of surface finish—has resulted in component-design staff avoiding a potential bottleneck with work of this nature by fabricating the part necessitating a long bore from a number of small details.

On the Continent, the difficulties associated with this class of machining have, within certain limits, been overcome. Instead of being an operation difficult to apply in the sense that the unit production time is an uneconomic figure, it is now quicker to produce a deep-bored component than to process a number of shorter parts. To-day it is possible to drill a hole in bar material from 6 ft to 15 ft in length at a higher rate of production than that obtainable by conventional methods of drilling in a lathe or a horizontal boring machine.

A further and sometimes even more important consideration is that, when necessary, it is possible to eliminate secondary finishing operations as, for example, honing. Surface finishes of the order of 0.5 to 1.0 micro-inch r.m.s. at a penetration rate of 8-10 in/min have been obtained in holes as small as $\frac{1}{4}$ in diameter in lengths up to 6 ft.

These very high feed-rates are the result of developments from German gun-boring practice obtaining in 1945. The methods now used in Germany and Sweden are parallel with the difference in speed between drilling with a twist drill and the trepan-boring method used for heavy engineering components. Because of the specialized

technique entailed, existing practice in this country should not be used as a basis in assessing the remarkable results achieved when boring materials ranging from steels having less than 0.2 per cent carbon in their composition to stainless grades and light-alloys with a high silicon content.

Most of the materials used in the automobile industry are within this range, while the non-ferrous group extends to the brasses. In view of this, components such as engine gear-blanks, bearing inserts of all kinds, gudgeon-pins, valve-seat inserts, diesel injector and pump parts, hydraulic cylinders, and to a certain extent, cylinder liners could be produced in 6-15 ft lengths of bar-stock material and cut to length after boring at a far higher rate of production than by methods in use at the present time.

There are three principal methods of boring by the German technique, which makes use of tungsten-carbide tipped tools. Each of these requires the use of a tubular boring bar for the return of the swarf during machining as in existing trepan-boring practice. By this process, oil at high pressure is pumped around the outside of the boring bar to the point of cutting, and returns through the centre of the bar, carrying with it the swarf produced.

As shown in Fig. 1, the equipment consists essentially of a horizontal boring machine of fundamentally heavy-duty lathe design. A high-pressure oil head, such as illustrated schematically in Fig. 2, is brought into contact with the free end of the workpiece to provide an oil seal. In operation, the boring bar passes through the high-pressure head and is controlled by the longitudinal traverse of the boring-head carriage. During the machining, either the workpiece or boring tool can

rotate, depending upon whether the workpiece is suitable for rotation, or both units can be rotated in a like or counter direction.

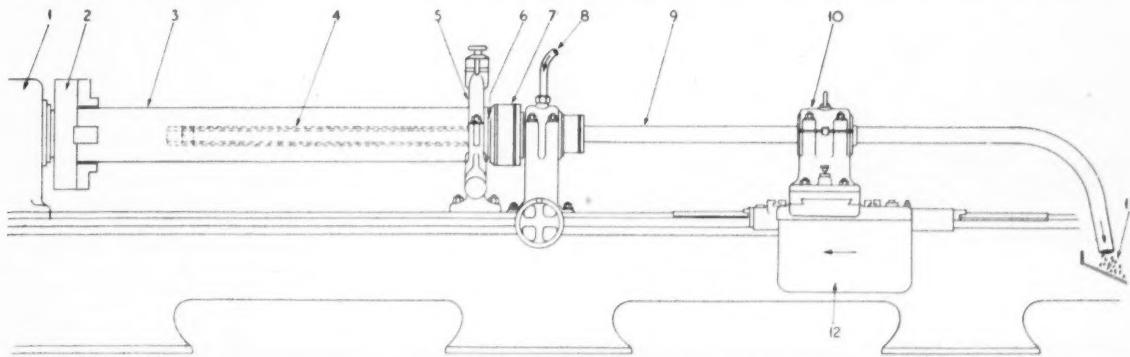
A pressure-head usually consists of two primary components: a stationary body, clamped directly on to the bedways of the machine or to a special saddle, and a free-running, circular-section member having either a rubber sealing ring or an entirely metal-to-metal seal. The bore through the body of the head and the rotating member is a slide fit on the boring diameter of the cutter. At the rear end of the head is a support bearing for the boring bar. Usually these bearings are in the form of an externally tapered, split-section hardwood bush to assist in damping-out vibration. With reference to Fig. 2, it will be seen that as the oil enters the head it is prevented from escaping in any way other than through the boring bar. As shown in other examples of actual heads, the rotating member is usually carried on one or more sets of ball-bearings.

Factors in design

One of the primary requisites in the design of this type of equipment is adequate power at the spindle. Existing machine tools of a size suitable for economic boring are underpowered for this operation, where a machine comparable in size to a 10 in swing centre-lathe requires up to 40 h.p. at the spindle. Any appreciable reduction in horsepower does not allow full advantage to be taken of the tungsten-carbide tipped tools. A secondary consideration arising from the use of high power is ample stiffness throughout and complete absence of vibration at all speeds.

To obtain the optimum rate of penetration the spindle speed and boring-bar

**Aircraft Production*



1, Headstock; 2, Chuck; 3, Workpiece; 4, Bored hole; 5, Roller-steady; 6, Oil-seal; 7, Oil pressure head; 8, Oil inlet; 9, Boring-bar; 10, Boring-bar headstock; 11, Swarf exit; 12, Carriage

Fig. 1. Semi-diagrammatic layout of a deep-hole boring machine

feed must be matched in relation to each other; the precise cutting condition necessary can only be realized by this means. This matching can best be achieved by the use of infinitely variable speeds and feeds that can be altered during machining. A variation in feed as small as 0.0002 in/revolution can cause an unsatisfactory chip to be produced and build up to form a blockage in the boring bar. This is a particularly important point, as current German practice is based upon using the correct speed and feed combination to produce the desired chip form, in preference to using a chip-breaker groove on the tool, when machining free-cutting steels.

The actual production of a satisfactory bore after the various mechanical considerations have been met is entirely dependent upon the cutting oil. In use, this oil has to perform three distinct functions which are:

1. Assist swarf removal.
2. Help the natural chip-breaking characteristics of the material.
3. Maintain the workpiece at a constant temperature throughout the boring operation.

To perform these three functions, the oil must be blended to suit the characteristic of the material being machined and not merely selected from a standard range of oils. In the light of current practice, the minimum pressure for satisfactory operation (depending, of course, upon the ratio in terms of diameter between oil entry and exit orifices) is between 600-700 lb/in² for the medium range of diameters rising to 1,000 lb/in² for small holes.

Boring-tool design

As mentioned in the introductory remarks, there are three principal methods of producing a deep hole by this technique. These are shown schematically in Fig. 3 and the upper diagram refers to what is known as the Beisner head, developed by Dr. Karl Beisner of Ruhrstahl A.C. Heinrich-

shuttle for gun-boring operations to replace the D-bit type of cutter. In common with all the boring heads, the Beisner pattern makes use of two tungsten-carbide tipped rubbing pads along the body of the tool. One of the pads is 180 deg opposed to the plane of cutting, and the other 85 deg to the plane of cutting, beneath the cutting edge. The cutting oil is forced around the outside of the boring bar, passing through two or more flutes in the head, returning with the chips through an irregular-shaped orifice in the face of the tool.

With reference to Fig. 7 it will be seen that the point of the solid-boring tool is offset from the axis of the cutter head so that there is at least a reasonable cutting speed at the small diameter. This type of head—integral with the boring bar—has been used for producing holes as small as $\frac{1}{4}$ in diameter to a depth of 6 ft. For large pierce-boring operations it is satisfactory up to 4 in diameter. The trepan-boring method, whereby a solid core of material remains after machining, is illustrated in the centre diagram, Fig. 3. This process is not to be recommended, however, for bores less than 1 $\frac{1}{4}$ in diameter if the machine has sufficient power to allow a high rate of penetration by the Beisner system. The reason for this will be appreciated when it is seen that a very small chip has to be produced to pass between the core of the stock and the inside diameter of the boring bar.

The third method, shown at the bottom of Fig. 3, employs a counterboring head; this type of tool can bore intermediate diameters after using a standard-size Beisner head. These counterbores are normally made from

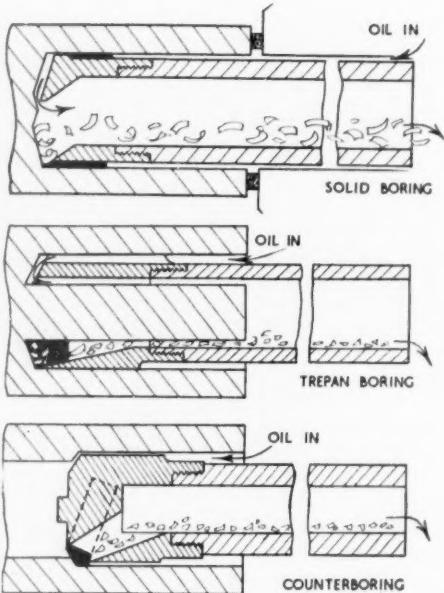
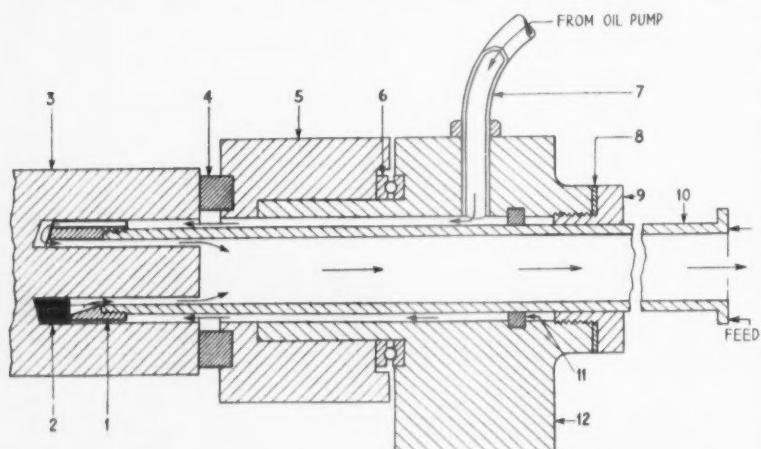


Fig. 3. The three principal types of cutter-heads, basically of German origin and developed by Heller

$\frac{1}{4}$ in diameter, where the cutter has a range of adjustment from a minimum of 0.004 in to about 0.1 in on diameter. In the larger sizes, a counterbore of 4 in nominal diameter has a cutting range from a minimum of 0.01 in to 0.7 in on diameter. It will be seen that the counterbore can be used in the same manner as a Beisner head for machining blind holes, as distinct from trepan boring where the bored hole must extend the full depth of the component. In the larger diameters the rubbing pads are detachable to effect a considerable economy as their life is greater than the cutting tip. The main advantage of these methods, apart from the increased rate of penetration as compared with the D-bit, is that the chips are conducted through the boring bar and do not abrade the surface of the bore with consequent loss in surface finish.

An example of trepan boring a relatively small diameter is shown in Fig. 4. This operation is carried out on a slightly modified No. 4 Gisholt turret lathe with portable boring equipment. The original method of machining the component consisted of drilling and reaming operations. The trepan-boring technique requires an average machining time of only 3 $\frac{1}{2}$ min, with the added advantage of a greatly superior surface finish. The component is supplied as a nickel-chrome steel forging (Spec. S11) measuring 13 $\frac{1}{2}$ in long and is through-bored 1.2 in diameter.

Preliminary machining consists of centering and rough turning the O.D. of the circular portion of the forging, and terminates at one end in a 20 deg included angle taper for a metal-to-metal oil seal in the pressure head, Fig. 5. The workpiece is loaded in a counterbalancing fixture, to eliminate vibration, and is held by a latch-type



1. Trepan-boring head; 2. Tipped tool; 3. Workpiece; 4. Rubber-seal; 5. Rotating body; 6. Thrust-bearing; 7. Oil inlet; 8. Rubber-seal; 9. Boring-bar support; 10. Boring bar; 11. Rubber-seal; 12. Main-body

Fig. 2. The principle of a typical pressure head. Oil is fed in at between 200/1000 lb/in² pressure in the stationary part of the unit and directed through the rotating member and around the outside of the boring-bar

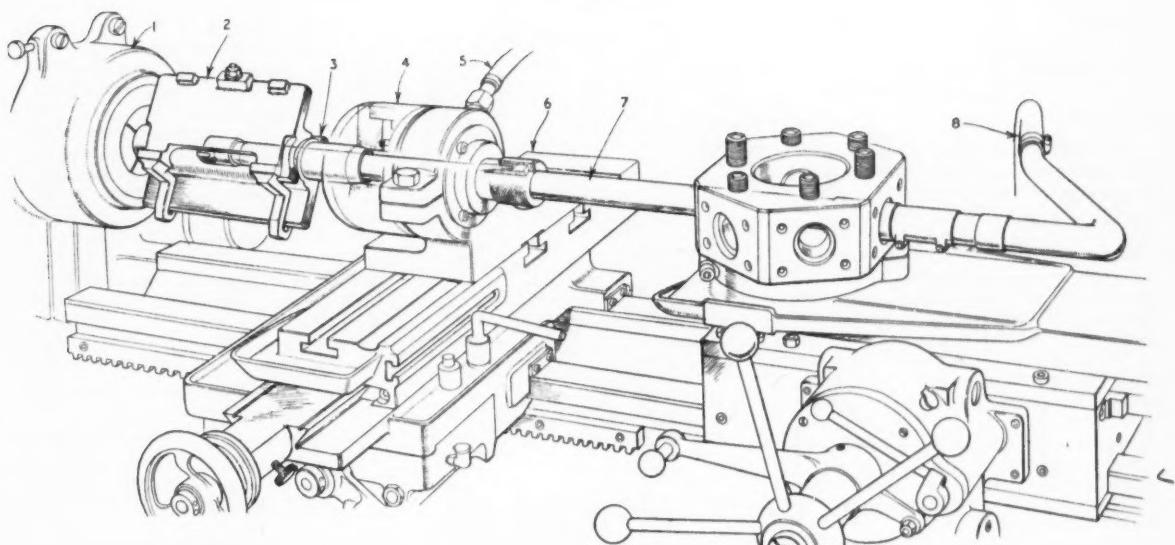


Fig. 4. Trepant boring on a modified No. 4 Gisholt turret lathe

clamp. The assembly is inserted into the collet-chuck of the machine and the pressure head, mounted on the cross-slide, is brought into contact with the free end of the part and is locked in that position. As seen in Fig. 5, the forging is held in the headstock of the lathe and located inside a length of thin-wall steel tubing, split at the collet end to allow the workpiece to be gripped, and sealed at the opposite end so that the cutting oil must return through the boring bar.

Sultran BI (Vacuum Oil Co. Ltd.) cutting oil is used, and this is delivered to the cutter head at a pressure of 200-250 lb/in² at the rate of 20 gal/min. About 250 gal of coolant is in use, and the oil returning from a circuit is filtered through a wire-mesh basket before re-circulation. Despite the seemingly short bore, the rise in oil temperature becomes very noticeable after a few components have been bored. This is indicative of the cutting pressures entailed in comparatively high-speed trepan boring, and the higher-than-normal load on the headstock bearings of a standard machine.

Although the trepanning heads, Fig.

6, are based upon the original German design (Gebrüder Heller, Bremen-Mahndorf*) much of the credit for satisfactory operation is due to the Martin-Baker Aircraft Co. Ltd., who are using the equipment and have redesigned the tip contour. To provide sufficient power at the spindle, a 10 h.p. motor has been fitted to the machine. Depending upon the hardness of a batch of forgings, a spindle speed range from 800-1,000 r.p.m. is used in conjunction with a feed rate of 0.005 in/rev. Providing that the cutter is not damaged in use, a total service life of a head is between 200-300 ft of boring.

Much of the recent development work in deep-hole boring has been concerned with the production of the smaller sizes of hole ranging from $\frac{1}{4}$ in to $1\frac{1}{2}$ in diameter, with the result that a number of commercially acceptable machines are in production and other designs are ready for manufacture. In this sphere, Heller have achieved a series of remarkable successes with their cutter-heads with a degree of consistency that eliminates the possi-

bility of freak results. The following figures can be regarded as typical of this development work on a production basis.

Material 54-60 ton tensile stainless steel, normalized

Solid boring 1.38 in diameter, tolerance ± 0.0004 in, with Beisner-type head, in lengths of $37\frac{1}{2}$ in

Feed rate

9.84 in/min

Material 85-92 ton tensile stainless steel

Solid boring 1.38 in diameter, with Beisner-type head, in lengths of $37\frac{1}{2}$ in

Feed rate

5 $\frac{1}{2}$ in/min

Material 38-44 ton tensile steel

Solid boring 0.47 in diameter, with Beisner-type head, in lengths of $23\frac{1}{2}$ in

Feed rate

9.45 in/min

Material 45-55 ton tensile stainless steel

Solid boring 0.326 in diameter, with Beisner-type head, in lengths of $27\frac{1}{2}$ in

Feed rate

5.98 in/min

*Heller boring heads are handled in this country by Wickman Ltd., Coventry.

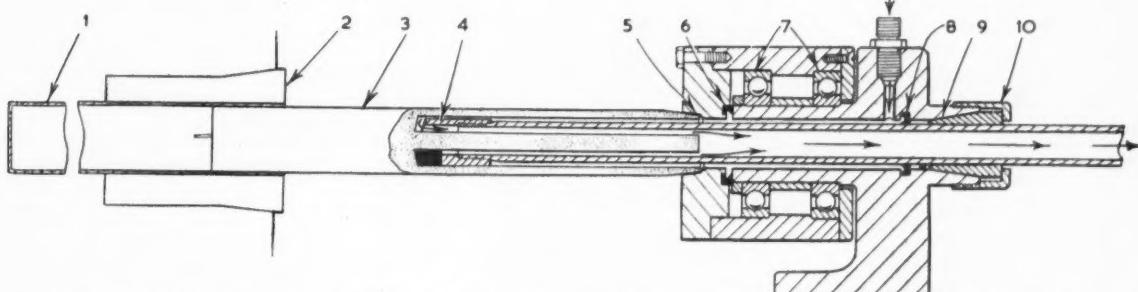


Fig. 5. Section through the Heller-designed oil pressure-head for the trepan-boring operation. A steel tube is fitted inside the collet to prevent oil from discharging through the headstock spindle

Material	70 ton tensile stainless steel
Trepan boring	3·15 in diameter, in lengths of 18 ft 6 in
Feed rate	5½ in/min

Although the depth bored in some of the foregoing examples is not very great due to component design, a similar rate of penetration could have been obtained for solid boring up to a depth of at least 15 ft. With work of this nature, the design of the oil pressure head can become a critical factor, and although a number of designs, a selection of which are shown in Figs. 8 to 11, are available, the principle of operation is similar to that shown in the schematic diagram, Fig. 2.

Heller have developed a number of standard heads of the pattern illustrated in Fig. 8 which are suitable for insertion into an existing housing or



Fig. 7. A Heller solid-boring head developed from the Beisner system

similar type of supporting body. This type of head in its standard form has a plain rubber sealing ring between the workpiece and the rotating member the face of which is formed with a square-section groove for retaining the sealing ring.

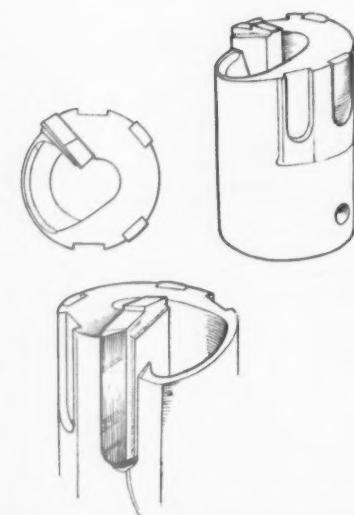


Fig. 6. Details of the trepanning cutters. The heads are manufactured from a high-tensile steel body with a single tungsten-carbide tool bit

Pressure head design

The V.D.F. group of companies (Vereinigte-Drehbank-Fabriken) makes a number of boring machines in two distinct ranges, the V.D.F. range manufactured by Heidenreich and Harbeck, of Hamburg 33, and the Boehringer range by Gebrüder Boehringer GmbH, of Goppingen*. Fig. 12 shows the rear view of model B3 V.D.F. machine. In this type of machine the pressure head, which has an integral pressure gauge, is traversed almost up to the work-piece, and the carriage clamped to the bed of the machine. With the main assembly rigidly held to the bed, the pressure-head component is advanced to make contact with the end of the workpiece by rotating a feed-nut by means of the spoked wheel.

One of the difficulties associated with deep-hole boring is the maintenance of the cutting oil at a constant low temperature to prevent linear expansion of the workpiece. This aspect of machining is important as, for all practical purposes, the workpiece is held between two rigid members—headstock and pressure head—and any appreciable rise in temperature must result in an increase of pre-loading on the headstock bearings of the machine. In certain instances, the thrust mechanisms have been overloaded to the extent of causing a bearing failure.

The extent of the increase in loading due to expansion can be ascertained from the following hypothetical example:

Temperature of workpiece at commencement of boring, 68 deg F
Maximum temperature of workpiece during boring, 140 deg F
Temperature rise, 140-68=72 deg F
Nominal coefficient of linear expansion for steel, 0·00000636 per unit length per deg F

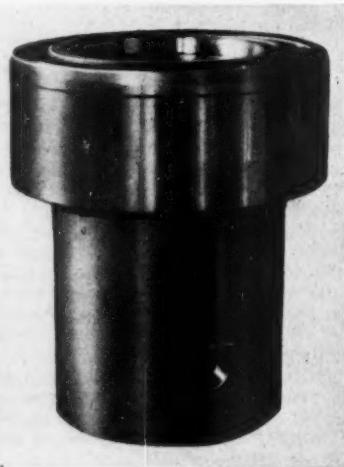


Fig. 8. One of the largest types of Heller pressure-head. There is a range of this type of unit

Nominal coefficient of linear expansion for aluminium 0·00001234 per unit length per deg F

On this basis, a steel component 9 ft long would increase in length by 0·0494 in and an aluminium component

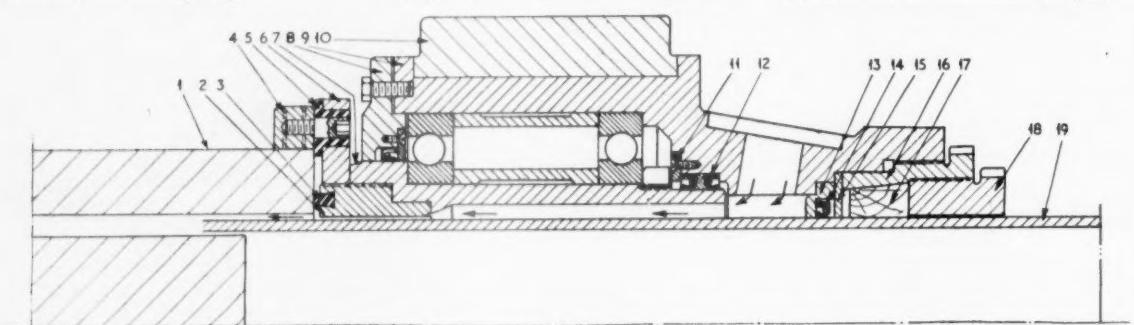
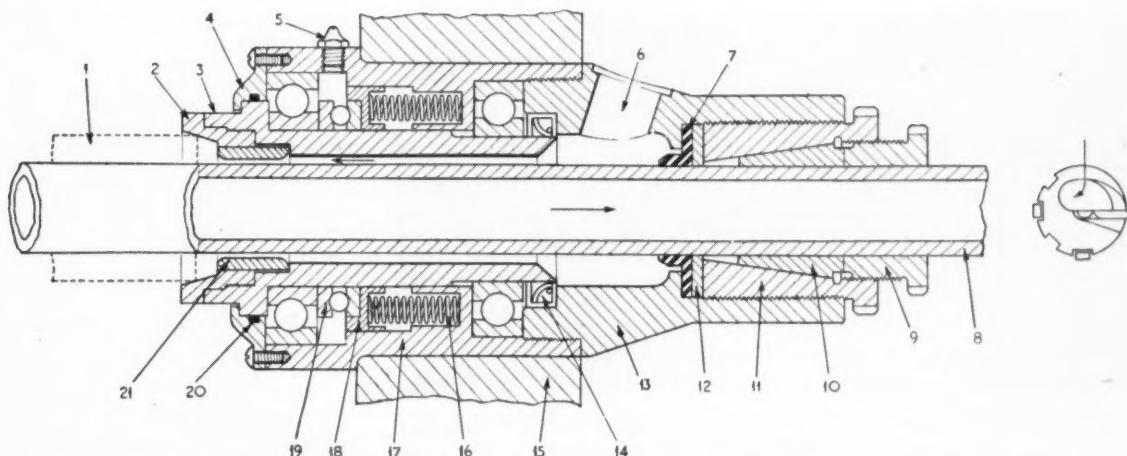


Fig. 9. Section through a Wagner pressure head. The oil-seal adapter is fitted to the outside diameter of the workpiece and held by through-bolts to the pressure-head component



1. Workpiece; 2. Metal seal; 3. Driving-bush assembly; 4. Cover plate; 5. Oil nipple; 6. Oil entry; 7. Rubber seal; 8. Boring-bar; 9. Lock screw; 10. Vibration-damping bush; 11. Seal lock screw; 12. Seal washer; 13. Body; 14. Oil-seal assembly; 15. Housing; 16. Compression spring; 17. Main body; 18. Thrust-absorption ring; 19. Thrust bearing; 20. Rubber seal; 21. Boring-head bush

Fig. 10. Details of a German spring-loaded pressure head for absorbing the expansion of a workpiece

by 0.0959 in. The two principal methods of overcoming the effect of this expansion are, first, the use of a larger flow of cutting oil when this is practicable, entailing the circulation of a much larger volume of oil, or the addition of refrigerating equipment in the oil reservoir to ensure that the oil is cooled before re-use and, secondly, a means of absorbing the expansion within the pressure head.

When the second method is the only practical solution, it is advisable to use a pressure head of the pattern illustrated in Fig. 10. Originating in Germany—the actual source unknown—it is suitable for either rubber-to-metal seal or entirely metal-to-metal contact between the head and workpiece. The body is made in two parts (13 and 17) and the assembly as a whole is fitted into the pressure-head housing. At the forward end, a metal-to-metal seal (2) is in contact with the workpiece. The seal is bushed internally (21) to suit the cutter head; the assembly is fitted into the main-bearing bushing (3) supported by ball bearings which are a press-fit around the outside diameter of the bush. A thrust bearing (19) is introduced between the ball-bearings and is fitted into a thrust-absorption ring (18), which has a number of pockets for retaining helical compression springs.

In use, the pressure-head is brought into contact with the workpiece in the normal manner to provide a seal, and in so doing, the main bearing-bush assembly is slightly compressed against the rear surface of the spring seatings. Any extension of the workpiece caused by heating is absorbed with the minimum increase of headstock bearing pressure.

Machine design

With the exception of the Carlstedt equipment mentioned later in this article, existing boring machines have the inherent fault of possessing stepped speeds and feeds. Because of this, the results obtainable are to an extent limited by the inevitable compromise existing between fixed ratios. Even with this handicap however the rates of penetration by this technique are at least double those obtaining at the present time by conventional methods, with the additional advantage of a markedly superior machined surface.

A good example of a machine conversion is illustrated in Fig. 13. This machine, originally a Loewe horizontal boring machine, has been converted for deep-hole boring by Heller, and is installed in their Bremen-Machindorf works. In this instance the cutter head rotates instead of the workpiece and the pressure head is integral with an

extended-length carriage which serves as a table for the workpiece. The workpiece is held by transverse strap clamps and an end clamp attached to the pressure-head housing.

As illustrated, the machine is being used for boring an 18-8 high-tensile steel billet. A Beisner-type solid boring head 1.58 in diameter is used for boring a hole 20½ in deep at a feed rate of 7.7 in/min. While the set-up is a temporary method for boring eccentrically located holes, a turret-type fixture could be used for long run production.

The V.D.F. machines, to which passing reference has already been made, are basically smaller versions of the Boehringer range. As will be seen from the various illustrations, the headstock is similar in design to the standard V.D.F. lathe but has a greater range of speeds and feeds. Another feature—but also common to the Boehringer range—is the duplication of primary controls on the pressure-head carriage and boring-head carriage. This form of duplication is an essential factor in the design of this class of machine where, owing to the use of cutting oil at high pressure, coupled with a high rate of tool penetration, it is necessary for an operator to have full control of the machine while he is on either side of the pressure head.

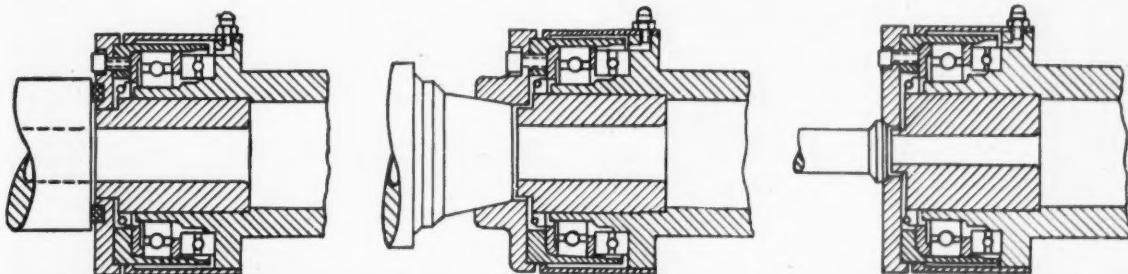


Fig. 11. Three methods of workpiece-to-pressure head seal used on V.D.F. machines. (Left) Conventional type of rubber-to-metal seal. (Centre) The preferred type of slow-taper metal-to-metal seal. (Right) Acute angle profile seal to suit component design. It is doubtful whether this type of seal is entirely satisfactory

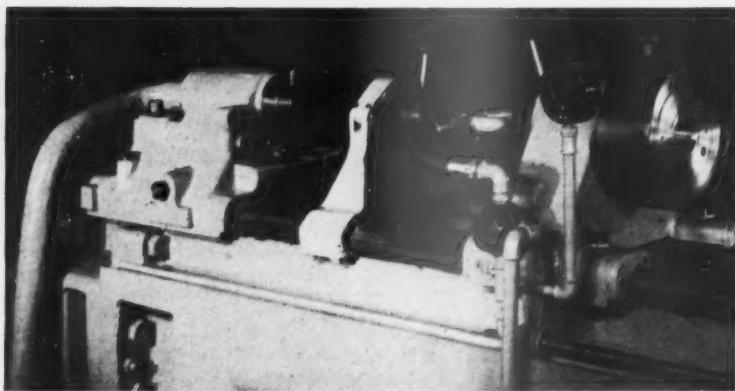


Fig. 12. Rear view of model B3 V.D.F. deep-hole boring machine, showing the adjustable-position pressure head

One of the methods used for securing a boring-bar to the boring head is shown in Fig. 14. Here, the end of the bar has a circular groove which is located by a sliding lock clamp. This type of fixing, of course, is only suitable for a stationary boring bar. When a rotating bar is used, it is customary to have either a collet-type lock or a flange fitting with through-bolt clamping. The oil return system shown in the same illustration has not proved entirely satisfactory because of constriction and many changes in direction; for this reason it has now been modified to allow a more direct flow.

The Boehringer machines, Fig. 15, are in the medium-to-large capacity class and can be supplied in two basic versions. The first design, Model B5 (as illustrated), has a stationary boring-bar, while the second type (Model B5B) has a combined rotary boring-bar. In addition to the basic design, two methods of headstock drive are available; the first uses a standard 20 h.p. motor mounted on a baseplate with tensioning brackets for a vee-belt drive, giving a range of 18 spindle speeds in a progressive ratio of 1:25. When this system is used, a double pole changing three-phase motor, or a two-

speed D.C. motor can be supplied. The second method of primary drive consists of a flange-drive motor giving a speed range of from 11.8 to 600 r.p.m. in the same progressive ratio.

Each method of driving has an adjustable multi-plate clutch which can be operated from the feed box, the boring head or the saddle. When the drive is disengaged, both the main-drive motor and coolant pump are stopped simultaneously. The power for the feed motion is obtained from the headstock spindle through a reversing-gear mechanism. A reversing-gear unit has been incorporated in the feed mechanism in order to carry out boring or reaming by the draw-cut principle: a range of 20 feeds can be obtained in a progressive ratio of 1:40 from 0.00047 in to 0.335 in/rev. Quick adjustment and rapid return of the boring head can be made at speeds between 3½-6½ ft/min.

In its standard form, the pump unit gives a coolant pressure of up to 284 lb/in², although equipment adapted to give pressures up to 711 lb/in² can also be supplied. This machine has a boring capacity of 4½ in diameter when using a Beisner or D-bit type head, and 7½ in diameter for trepan boring. Available in a number of bed-lengths,

the smallest machine can handle work up to 3 ft 3 in in length and the largest, work up to 19 ft 8 in in length.

The Carlstedt* range of deep-hole boring machines mentioned in the November issue of *Automobile Engineer* (pages 481-2) represents the latest practice in the design of this class of equipment. A typical result claimed by the manufacturer is:

Material High-alloy steel
Solid boring Beisner - head method, $\frac{1}{2}$ in diameter, in 6 ft lengths

Feed rate 6½ in/min. Maximum eccentricity at the breakthrough end, 0.0012 in. Tool life between regrinds, 65-78 ft of penetration.

A feature of this machine (Figs. 16 and 17) is the ready accessibility of the headstock for loading the work at the rear of the machine. This arrangement, coupled with a pneumatic work-holding chucking system, allows the incorporation of a roller-type conveyor loader where the component to be bored is allowed to roll into the loading position on the machine immediately the machined component has been released from the fixture into the delivery chute.

Vertical boring

Equipment suitable for parts of shorter length or forgings of complex shape is built by Hille-Werkzeugmaschinen GmbH, of Witten-Annen, Ruhr, Germany†, on the unit construction principle for battery operation. A typical double-spindle machine of this type is shown in Fig. 18. This class of machine is used for boring either batch-production or quantity-production parts in the inverted position. The part to be drilled or bored is held in a chuck or fixture above the cutting tool. As illustrated, the machine is equipped with a high-pressure oil head and a Beisner-type boring tool. Here, the oil is pumped upwards through the pres-

*Now handled in this country by Wickman Ltd., Coventry.

†Handled in this country by the Rockwell Machine Tool Co. Ltd., Welsh Harp, Edgware Road, London N.W.2.



Fig. 13. Another Heller pressure head is integral with the carriage. Here the boring-bar is rotated instead of the workpiece

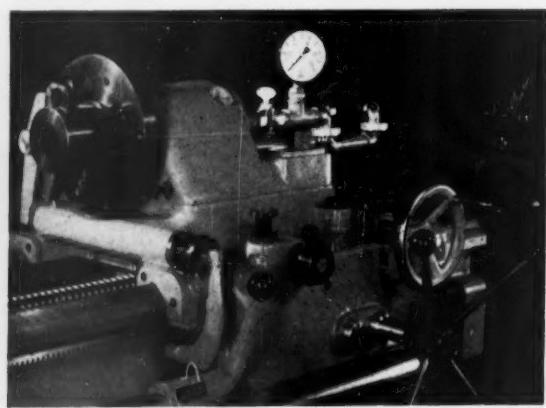


Fig. 14. Method adopted by V.D.F. for securing a stationary boring-bar

sure-head and around the outside of the boring-bar, returning through the centre of the bar and escaping through the cut-out shown in the fixed-head fitting in the swarf tray. Known as type BST 25.2, a performance figure claimed for a machine of this type is as follows:

Material Steel, composition C 0.27,
Si 0.28, Mn 0.3, Cr 1.5,
Ni 4.5, Mo 0.5, T 4.5,
V 0.2

Boring diam. 0.669 in with Beisner head

Boring depth 5.102 in

Output Floor-to-floor time 2.9 min per part per spindle.

The advantages of this type of machine are the relative ease of production once the machine has been set for an automatic cycle, and the ready incorporation of special work-handling jigs or fixtures to ensure repetitive alignment. A disadvantage, from the point of view of deep-hole drilling, is that it is not equipped with infinitely variable speeds and feeds.

Cutting oil

In deep-hole boring, success is perhaps more dependent upon the active co-operation of the cutting fluid than in any other metal-removing process. Because of the nature of the operation the oil is, in effect, the third of the basic requirements, of which the other two are machine and cutter head. There are a number of requirements that all cutting oils must meet. These are, briefly, heat removal; ability to wet the metal efficiently so that cooling may be as effective as possible; maintenance of tool life, which is dependent upon viscosity in order that the oil will remain at the cutting edge while still allowing easy circulation and swarf removal; anti-welding properties; fluid stability with freedom from separation in use; and a minimum tendency to fuming.

This class of boring creates an arduous set of conditions for the fluid and, because of this, neat oil of the active type should be used. The terms "active" and "inactive" oils, refer to

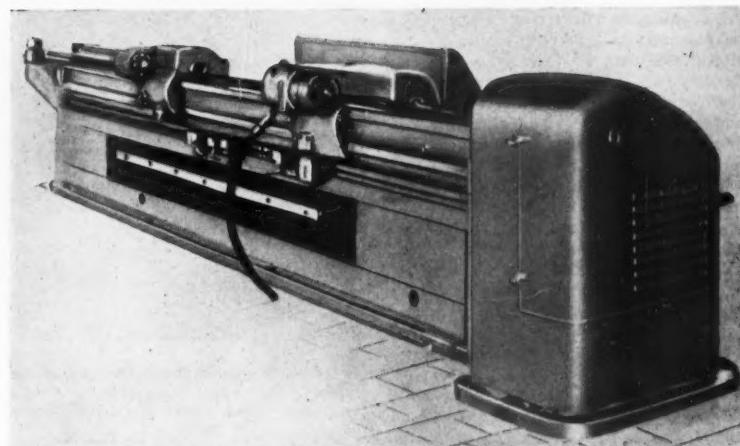


Fig. 16. The basic version of the Carlstedt (Swedish) deep-hole boring machine. The smallest version can be used for boring holes $\frac{1}{4}$ in diameter

the chemical activation of certain constituents in the oil which react on the surface of the work to improve cutting conditions. These resultant reactions are affected by the pressure and temperature of the work at the point of cutting and with the susceptibility of the workpiece to the chemicals.

The purpose of these compounds is to prevent the adhesion of swarf at the point of the tool, and subsequent generation of a roughened surface on the workpiece. Although fatty oils, which are of the polar type, have a good effect upon boundary friction, the application of mineral fatty oils has diminished over the years in favour of the "extreme-pressure" (E.P.) oils. These oils possess greater anti-welding properties and contain further additives to allow them to withstand high pressures between the workpiece chip and the tool. Following the discovery of the application of free sulphur to cutting oils came the steady and continuing development of E.P. oils. Fluids of this type have a still greater tendency to react at the point of cutting, giving rise to the formation of a strong chemical film between the two surfaces. The additives in present day

E.P. oils to create this film contain either or both sulphurized and chlorinated properties. Apart from laboratory tests combined with actual performance tests, the only short cut in testing procedure is to experiment with a selection of fluids containing known additives and to vary the percentage of these additives until the desired degree of stability in production is achieved.

Chip formation

One of the primary functions to be established in the selection of cutting oils is the mechanism entailed when a metal is machined. By the use of contemporary photographic and metallographic equipment three basic chip forms have been established and these are the result of two fundamental processes. These comprise a shearing process whereby the initial chip form is created, followed by the movement of the chip up the face of the tool. It is now generally accepted that the three basic chip forms (equally applicable to boring) produced during machining are: continuous chip, continuous chip with built-up edge, and the discontinuous chip.

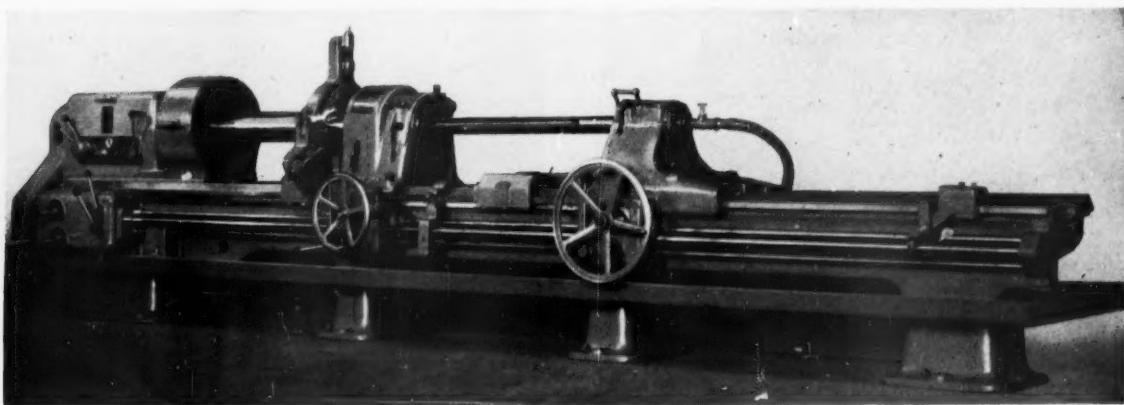


Fig. 15. The Boehringer model B5 boring machine with a D-bit head in position. This machine is also available in the combined rotating-bar version, when it is known as model B5B

A continuous chip is produced when the material is continuously deformed without rupture to flow smoothly up the tool face. The conditions responsible for this effect on ductile materials are a fine feed, high cutting speed, efficient cutting fluid and a keen cutting edge. The continuous type of chip with a built-up edge is most likely to take place with tough but ductile materials, and is brought about by high frictional resistance as the chip passes across the face of the tool, resulting in some of the material being sheared away before the body of the chip leaves the workpiece. Here, unless an active sulphurized oil is used, localized welding can take place. The conditions most likely to give rise to this effect are: ductile material, low cutting speeds, coarse feed and inefficient cutting fluid. When the built-up edge effect is of only slight proportions, it is not necessarily a fault, as it can serve to protect the tool. When possible, however, the heat of the molecular disturbance and the pressure should be used to force the surface-active bodies of the oil into the micro-fissures to form a solid metallic sulphide film of solid lubricant to prevent welding between chip and tool. With the discontinuous chip form, the shear stresses exceed the shear strength of the material and are the result of a small rake-edge on the tool, brittle material and low cutting speed.

To obtain a high grade surface finish, it is safe to give the order of preference of material chip forms as:—

1. Continuous chip with artificial breaking.

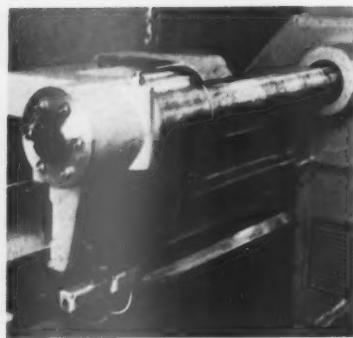


Fig. 17. Rear view of the Carlstedt machine showing the neat arrangement of the headstock which permits quick work-handling

2. Discontinuous chip with brittle material.
3. Discontinuous chip with low friction on ductile materials.
4. Continuous chip with high friction.

The principal factor known to have the greatest effect upon surface finish is the coefficient of friction between the tool and workpiece, and a reduction in this value will usually have the desired effect.

General conclusions

The technique of deep-hole boring, while apparently a relatively simple process, is in practice rather the reverse. Considerable power is required at the spindle for the mere act of removing the volume of metal which, in turn,

necessitates a structure capable of withstanding the thrusts generated. An equally important consideration is the provision of infinitely variable speeds and feeds or, at least, an infinitely variable feed. When a free-cutting material is being machined that does not require a chip breaker groove on the tool, extreme sensitivity of feed control to within 0.0002 in/rev can be important. In achieving this accuracy, the actual sensitivity of control on the part of an operator is also a factor; this requires a machinist of toolroom standard. To allow quick interchangeability, the design of a pressure head should be conceived as a unit for insertion into a housing integral with the machine. On the subject of cutting fluids, the position in this country is necessarily one of experiment. There is no apparent reason why a sulphon-chlorinated compound would not be eminently suitable providing that the question of sulphur-release temperature can be held within narrow limits.

Additional practical knowledge is also required to determine exactly the right chip form and hence the right tool angles. The only satisfactory approach to the compilation of accurate data of this kind is a methodical analysis. The process as a whole is a comparatively new method of production, and as such requires a certain amount of time to develop the most suitable means of incorporating it into an existing manufacturing programme. Whatever course is adopted, however, this technique will allow a considerable increase in the rate of production with the minimum of extra floor space.

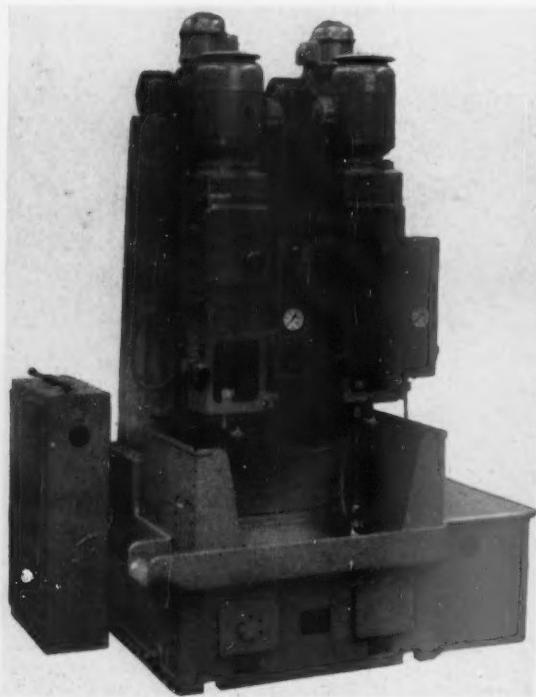


Fig. 18. A Hille deep-hole boring machine fitted with a Beisner type cutter head for boring finished-machined spindles

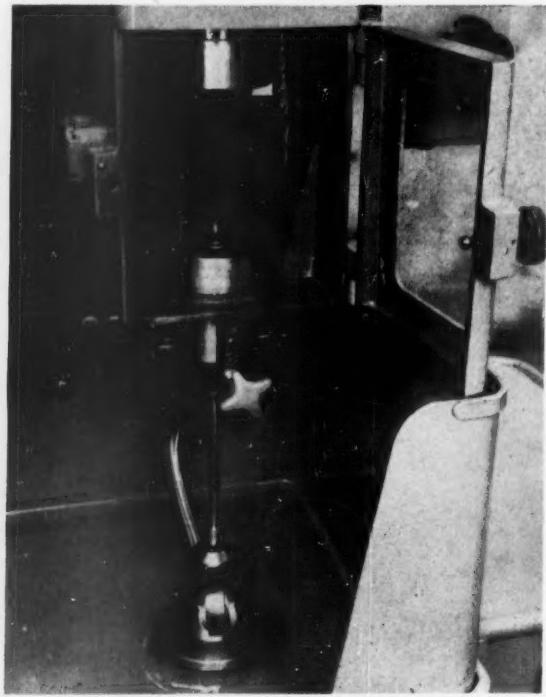


Fig. 19. Details of the Beisner-head boring system fitted to the Hille machine



BALL AND ROLLER BEARINGS

When names such as Napier and Star were the talk of the day in the car world and Dr. Lanchester was pioneering his 3-wheeler, Hoffmann Bearings were already renowned for their reliability. In 1908 a Napier fitted throughout with Hoffmann gained 28 world's records. Today, as ever, they are instinctively the choice of designer, manufacturer and engineer.

THE HOFFMANN MANUFACTURING CO. LTD., CHELMSFORD, ESSEX

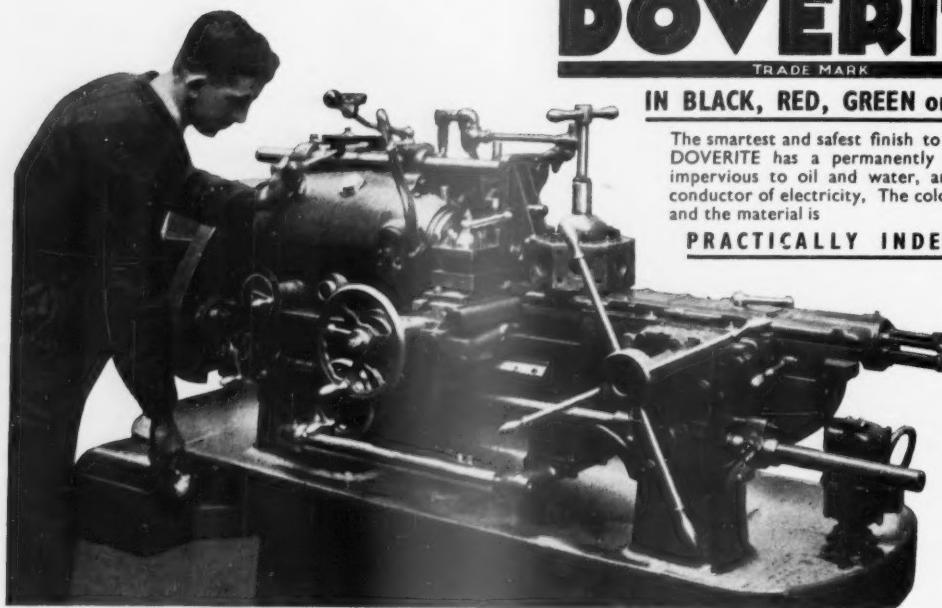
HE CAN SEE AT A GLANCE
these HAND CONTROL WHEELS, Knobs & Handles

if covered or moulded in

DOVERITE

TRADE MARK

IN BLACK, RED, GREEN or other COLOURS.



The smartest and safest finish to modern machine tools, DOVERITE has a permanently polished clean surface, impervious to oil and water, and is an efficient non-conductor of electricity. The colour is solid throughout, and the material is

PRACTICALLY INDESTRUCTIBLE

We cover Manufacturers own parts or supply a standard range of Hand Control Wheels from 3½in. to 12in diam. and Moulded Knobs and Handles with the threads moulded in DOVERITE, strong enough for most purposes.

**DOVER LIMITED,
NORTHAMPTON.**

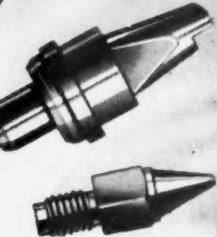


Cutting
AND
WELDING
NOZZLES

Over 100,000 of all
types and sizes
carried in stock

**SPECIAL DISCOUNTS
FOR QUANTITIES**

SOUTH END,



Send your enquiries to:

POLLOCK & PEEL
Limited
ENGINEERS

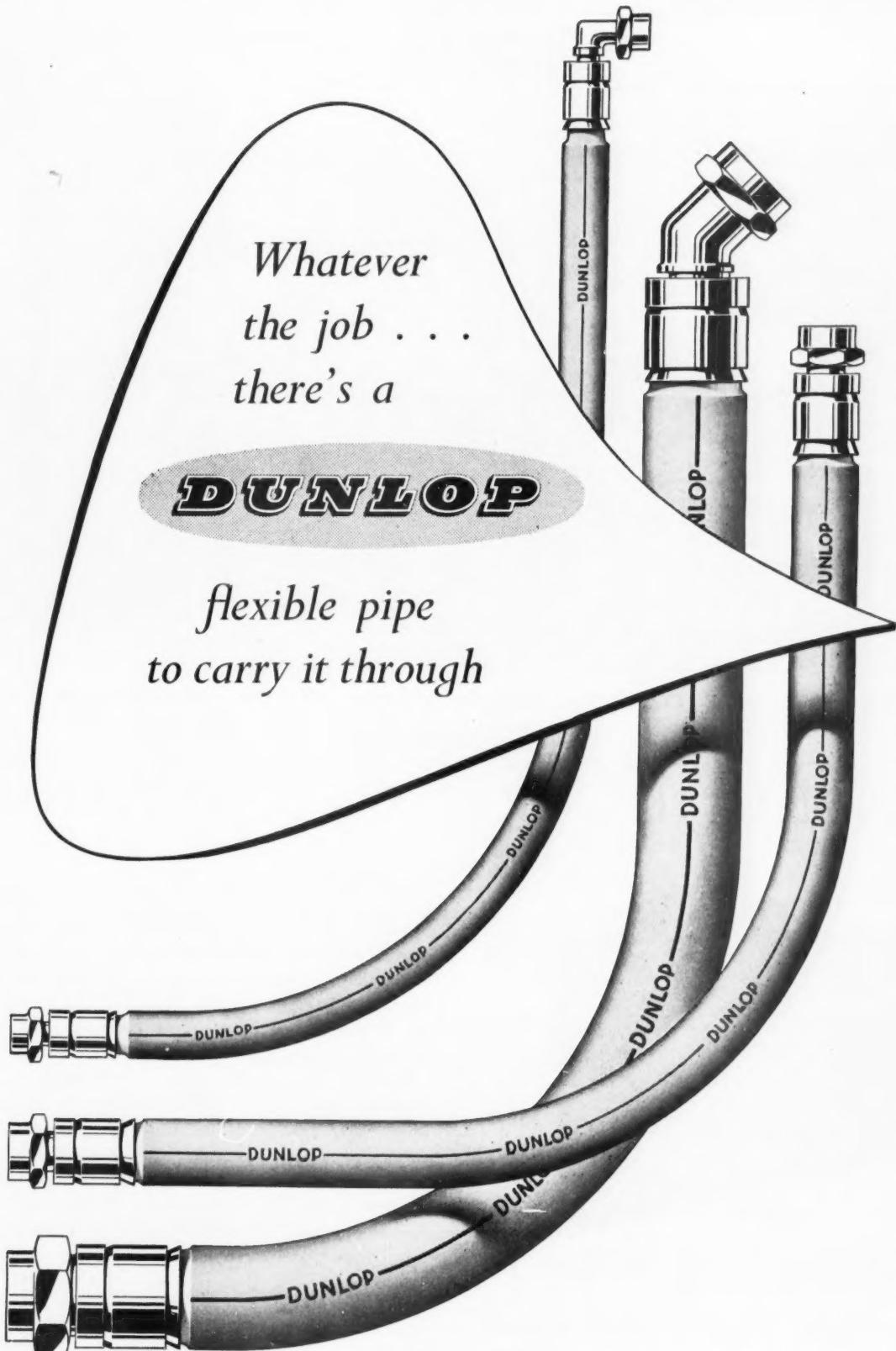


CROYDON, SURREY, Tel: CROYdon 3158/9

*Whatever
the job . . .
there's a*

DUNLOP

*flexible pipe
to carry it through*

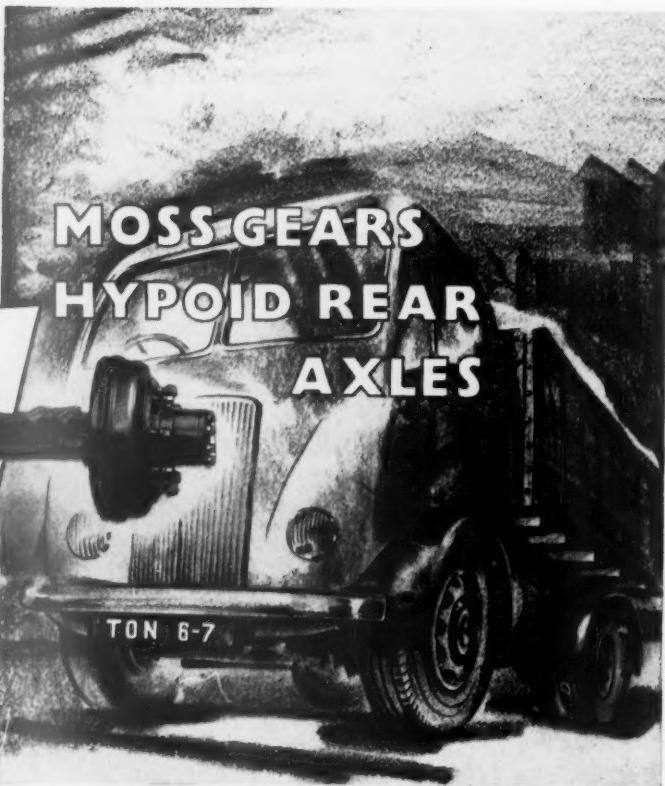


Dunlop technicians will always advise on any problems concerning installation of flexible piping. Write please to :—

DUNLOP RUBBER COMPANY LIMITED • ST. GEORGE'S ROAD • COVENTRY • TELEPHONE: COVENTRY 84171

SH/904

**The makers of the
World's most Rugged
Trucks Specify . . .**



THE MOSS GEAR CO., LTD., CROWN WORKS, TYBURN, BIRMINGHAM, 24
'Phone: ERDington 1661-6.

'Grams: "Mosgear, Birmingham."

6347

MAGNETIC CRACK DETECTION



The Metroflux Type "S" universal magnetic crack detector is an extremely flexible unit. It is of great value for testing components of large size or awkward shape, and for routine testing of mass-produced components.

IS SIMPLE AND SURE

Even when too fine to be detected by any normal inspection method, surface cracks can be discovered immediately with Metrovick magnetic crack detection equipment. Developed primarily for practical tests on components produced in the company's own factories, ranging from large forgings to small pinions, this Metrovick equipment is very simple in operation. Use is made of a special magnetic fluid which, after passage of the magnetising current, enables all cracks to be seen with the naked eye. Most requirements in industry can be met from the standard range of Metrovick crack detectors. Special equipment can, however, be made to order.

Please write for full technical details.

METROPOLITAN-VICKERS ELECTRICAL COMPANY LIMITED, TRAFFORD PARK, MANCHESTER, 17
Member of the A.E.I. group of companies

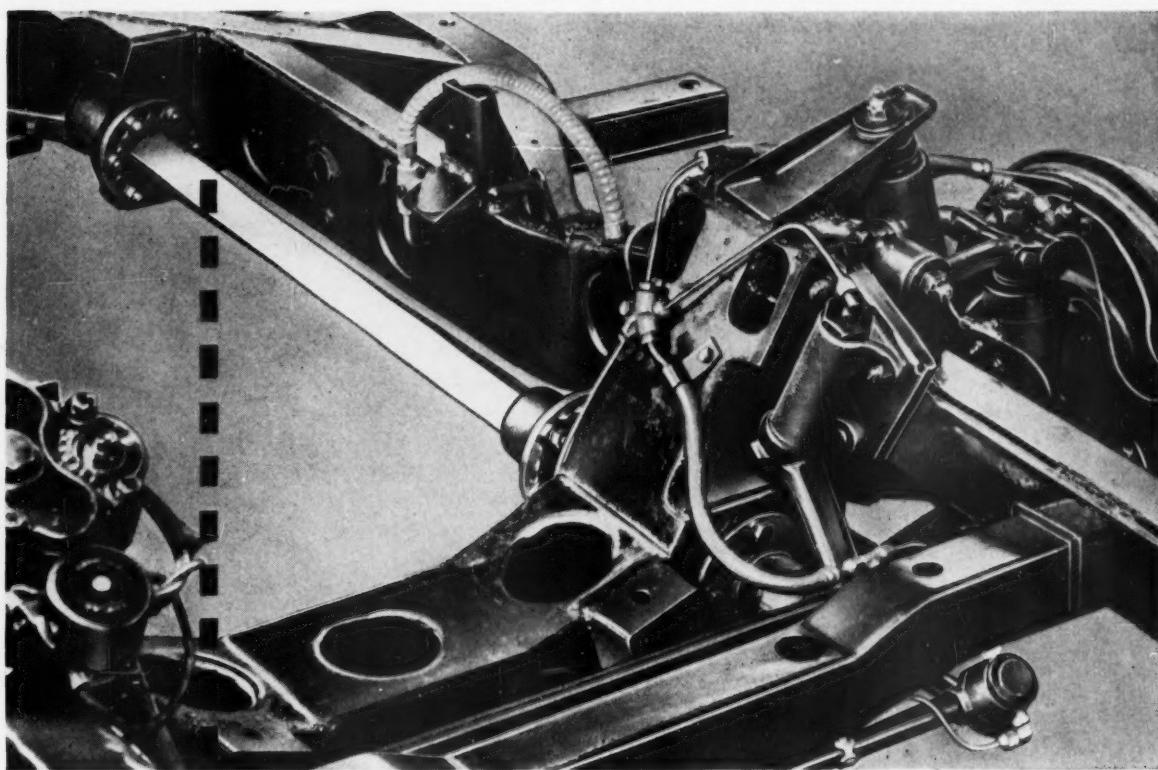
METROVICK

Magnetic Crack Detectors



N/C21

Photograph by courtesy of The Daimler Co. Ltd., Coventry, and "Automobile Engineer".



SALTER LAMINATED TORSION BARS save

SPACE — the smallest suspension unit possible

MONEY — the production process is not costly

TIME — fitting to any chassis is simple

Our designers would be glad to co-operate with your development engineers as to how Salter Laminated Torsion Bars can be incorporated on your future models

GEO. SALTER & CO. LTD., WEST BROMWICH

M.W.369



200 miles at 125.87 M.P.H. is a solid enough record, and that is what Jack Fairman and Lance Macklin did in the Bristol 450 at Monthlery when they captured six Class E International Records.

The reliability of the chassis was an important factor, but the chassis itself was not solid. It was a tubular job made from Accles & Pollock tubes.

The advantages of tubular chassis have persuaded many designers to use them, others who would like to find out more about them are invited to get in touch with Accles & Pollock. They can supply tubes in the straight or made up into chassis to customer's specification; and a wealth of specialised experience is freely available.

ACCLES & POLLOCK LTD. Steel Tube Makers and Manipulators
OLDSBURY • BIRMINGHAM

A COMPANY

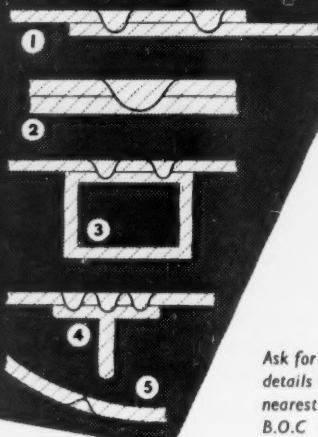
TBW/M2A

*These difficult welds are simple
with B.O.C ARGONARC
Equipment*



ARGONARC AUTOMATIC SPOT WELDING

achieves full fusion with application to only one side of work, joins thin to thick sections, and requires no skill, no goggles, no screens. Fast flux-free welding on stainless steels and bright mild steel. A weld can be made wherever the compact torch can be positioned. The apparatus is transportable.



Ask for full details at your nearest B.O.C Branch

- 1 Lap joint spot welded from above
- 2 Outline of spot in 20 g. stainless steel
- 3 Sheet spot welded to box section
- 4 Stainless steel sheet spot welded to mild steel T-section stiffener
- 5 Cylindrical section tack welded externally



THE BRITISH OXYGEN CO LTD

LONDON & BRANCHES



**designed with
the job in mind**

Made by James Neill & Co. (Sheffield) Ltd. and obtainable from your usual supplier.

EG116



When slow motion speeds production!

In addition to normal speeds, CLAYTON HOISTING GEAR with MICRO SPEED UNITS provide DEAD SLOW hoisting, lowering and travelling on Alternating Current. For Machine Assembly, the precise positioning of heavy parts between centre lathes and in Foundries for handling Cores and Moulds, the CLAYTON MICRO SPEED UNIT is unsurpassed.

Cheap to install, simple to operate and maintain and completely reliable, the CLAYTON MICRO SPEED UNIT is enabling many progressive firms throughout the country to cut their costs and reduce their overheads.

May we send you details?



THE CLAYTON CRANE & HOIST CO. LTD.

IRWELL CHAMBERS EAST · UNION STREET · LIVERPOOL, 3
Telephone: CENtral 1141 (4 lines) Telegrams: Claymag, Liverpool
REPRESENTED IN ALL PRINCIPAL COUNTRIES

CLAYTON

ALL BRITISH
HOISTING & HANDLING EQUIPMENT
OF ENDURING QUALITY

CH 31

Get these SPRAYLOGICS Booklets-FREE!



Three unique guides to greater paint shop efficiency — packed with vital information on the DeVilbiss-Aerograph "know-how"! If you haven't yet asked for your copies, write today to Dept. 6V — before the present editions are exhausted.

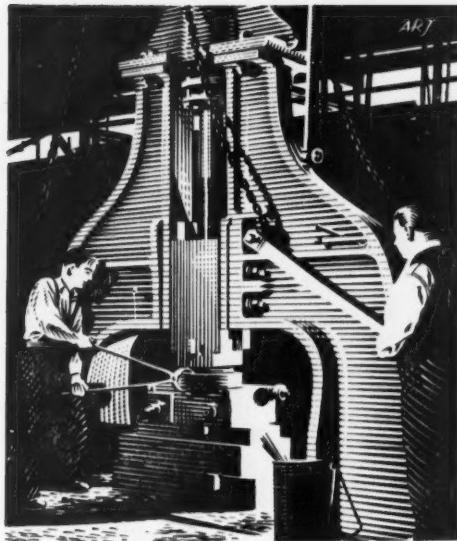
DEVILBISS AEROGRAPH

The SYMBOL  of SERVICE

The Aerograph Co. Ltd., Lower Sydenham, London, S.E.26. Telephone : Sydenham 6060 (8 lines)

BRANCHES AND SHOWROOMS: LONDON, BIRMINGHAM, BRISTOL, GLASGOW, MANCHESTER

T.A.5406



What will a purchasing agent pay —for Tradition?

If by Tradition you mean nothing but a perpetual harking back to old-fashioned ways and the Chairman's great-grandfather, then the answer is—Nothing!

But even the toughest buyer knows that there is value in dealing with a firm of individuality and character, despite the fact that it was founded in 1778.

The 1500 workers at Doncasters of Sheffield embody old skills informed and transformed by scientific knowledge of materials

and treatment and applied to the output of modern plant of high productivity.

Doncasters supply largely to buyers in the transport and engineering trades who have a need for drop forgings, valve stampings, bars of tool or other tough hard steels, and steel forgings both light and heavy.

Such men buy keenly, but not so keenly that they do not value high quality, service and integrity of craftsmanship.

DONCASTERS 
1778 DD

DANIEL DONCASTER & SONS LIMITED • SHEFFIELD
FORGINGS • DROP FORGINGS • HARDENED STEEL ROLLS • HEAT TREATMENT



P11



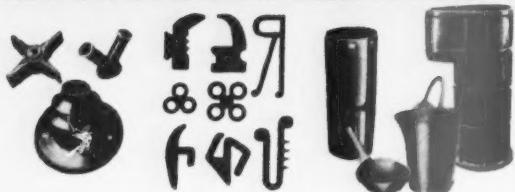
What's your problem?

Insulation? Protection? Silencing? Sealing?

Simple or complex, Redfern's will help to solve it. We have the experience, capacity and resources for economical bulk production of moulded components and extruded sections in natural and synthetic rubbers, and ebonite. Plan with all the knowledge of our technical staff at your elbow—we are always pleased to advise on the use of these versatile materials, and translate designers' ideas into terms of efficient production. Send us your enquiries—we will do the rest!

Literature is available describing our service—MOULDINGS . . . EXTRUDINGS . . . anti-corrosive LININGS & COVERINGS . . . FLOW FITTINGS (piping, cocks, tees, etc.) . . . chemical-resisting UTENSILS . . . FABRICATED PARTS to specification.

A request to add your name to our mailing list will keep you up-to-date with publications dealing with any of these items.



MOULDINGS — EXTRUDINGS — FABRICATED PARTS AND UTENSILS

REDFERN'S RUBBER WORKS LTD • HYDE • CHESHIRE

T.P.112

REDFERN

RUBBER & EBONITE

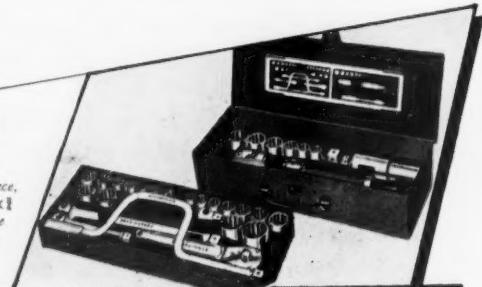
WILL HELP YOU SOLVE IT!

Entirely New!

A new and improved tool with an old name—Garringtons—the hallmark of quality. For ease and versatility it is unequalled. Finely finished with major surfaces mirror polished, the sets are forged by a new process which combines great strength with light weight. The boxes are of high grade steel, stove enamelled in maroon.

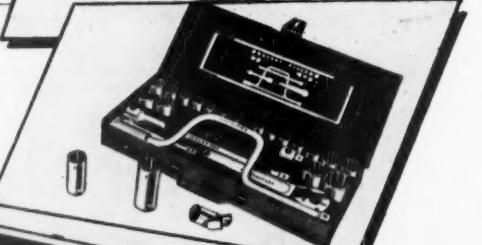
26 SET BOX (BACD)

Supplied with Speed Brace, Tommy Bar, Tee Piece, Ratchet, Universal Joint, 6" and 12" extension, $\frac{1}{2} \times \frac{1}{2}$ Converter Driver and $\frac{1}{2} \times \frac{1}{2}$ Converter Driver. Space available in box for additional tools—Great Shua, Spanners, Screwdrivers, etc.



18 SET (BACC)

Speed Brace, Tommy Bar, Tee Piece, Ratchet 6" extension and 12" extension. Space for optional additions of 14 and 18 mm. Sparking Plug Sockets and Universal Joint.



6, 10 & 12 SET BOXES

All supplied with Tommy Bar, Tee Piece and 6" extension, Ratchet and Universal Joint can be added as extras. Available in Whitworth American and United sizes.



GKN

PELICAN
BI-HEXAGON
BOX SOCKET SETS

GARRINGTONS LTD • BROMSGROVE WORCS • DARLASTON STAFFS

Garringtons

Why you should..

..fit the M.M.D.Clevis!

Positive brake linkage...

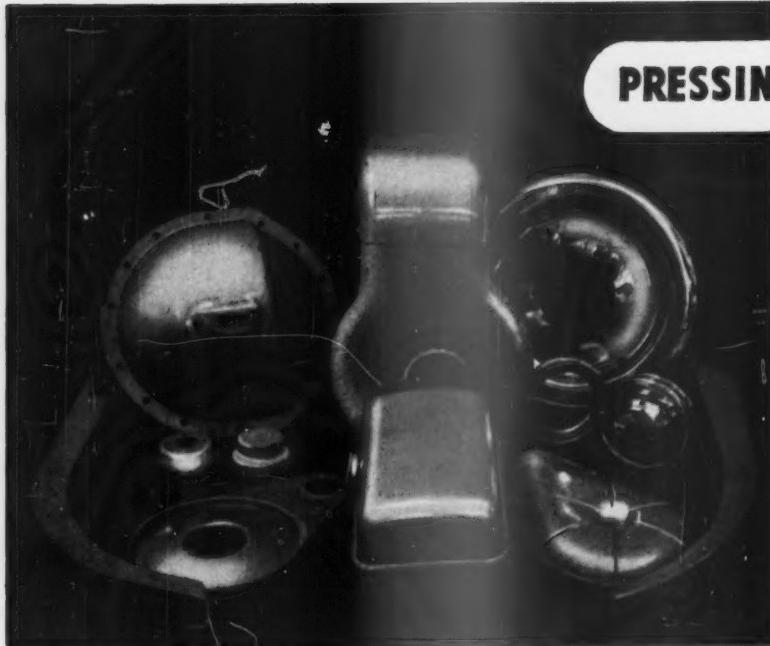
... ensures more positive braking, and the M.M.D. Spring Loaded Clevis Joint is the finest solution to the problems of "sloppy" brake linkage and repeated adjustment. Wear, slack and rattle on all mechanically-operated linkages can be eliminated throughout the life of the car with the aid of this rationalized clevis joint. Available to suit all requirements of the Motor Industry.



MIDLAND MECHANICAL DEVELOPMENTS LTD.
PARKER STREET WORKS • PARKER STREET • BIRMINGHAM 16

R. & W.

PRESSINGS & FABRICATIONS



The items illustrated show only a few of the automobile components manufactured by us for the automobile trade in our self-contained factory.

We manufacture our own Press Tools; Fabrications, Spinnings, Assemblies, and are able to undertake all kinds of Metal Finishes.

ADAMS BROS. & BURNLEY LTD.

Elmgrove Road, Harrow, Middlesex.
Telephone: HARROW 6411 (5 lines)

AIR CLEANER ASSEMBLIES — PETROL TANKS — WING COVERS — WING STAYS

Economically
produced with
Multi-tool set up

DAWE

Sound Level METER

TYPE 1400

for measuring the intensity of sound level over the full-audible range.

Designed for use with
Type 1401 & 1404 for analysis
and vibration measurement



Technical data from: DAWE INSTRUMENTS LTD, Instrument Division,
130 UXBRIDGE ROAD, HANWELL, LONDON, W.7 : EALING 6215
or from your Regional Agent

Midlands
Hawnt & Co. Ltd.
59 Moor Street,
Birmingham, 4
Central 6871

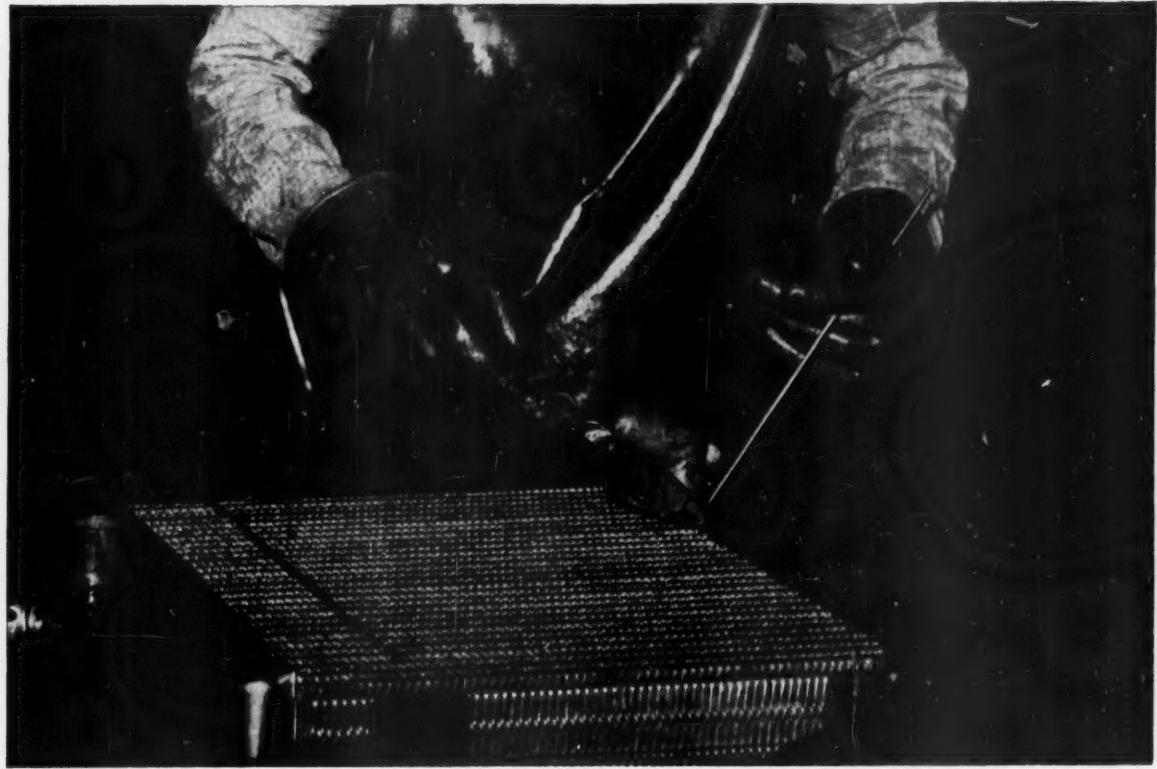
North of England
A. C. Farnell Ltd.,
15 Park Place,
Leeds, 1
Leeds 32958

Cheshire
F. C. Robinson & Ptnrs.
287 Deansgate,
Manchester, 3
Deansgate 6601

Scotland
Land, Speight & Co. Ltd.,
73 Robertson Street,
Glasgow, C.2
Central 1082

West of England
Radford Electronics Ltd.,
4 Acraman's Road,
Bristol, 3
Bristol 64300

Northern Ireland
James Lowden & Co.
11 Middlepath Street,
Belfast
Belfast 57518



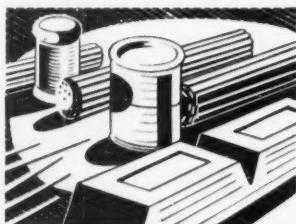
Photograph by courtesy of Vauxhall Motors Ltd.

Britain's most modern automobile plants

USE ENTHOVEN SOLDERS

The unique standards of purity and quality to be found in Enthoven Solders are an essential aid to the perfect operation of modern production technique. These standards are maintained by constant laboratory control during all stages of manufacture.

Enthoven Tinmans, Blowpipe, Ingot and Solid Wire Solders are supplied to B.S. Specifications 219-1949 and customers' special specifications.



Enthoven Body Solder is supplied in sticks to standard specifications or special alloys.

Entocene Solder Paint for pre-tinning on body work and for certain sweat soldering work is easy to use, clean and economical in operation. Our technical advisers and laboratory staff are available for consultation. Technical data, descriptive literature and samples gladly sent on request.

ENTHOVEN **SOLDER PRODUCTS**

ENTHOVEN SOLDERS LTD., 89, UPPER THAMES STREET, LONDON, E.C.4. TELEPHONE NO: MANSION HOUSE 4533. TELEGRAMS: ENTHOVEN PHONE LONDON 4533



On the "Mauretania" and the two "Queens", on railway systems throughout the world, certainly in your own car, Cooper's Felt is proving an invaluable material for a surprising number of purposes. Have you considered felt? One of Cooper's experts will be happy to answer any questions.

COOPERS FELT

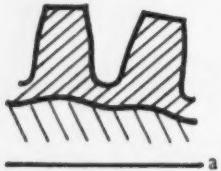
Please send all enquiries to—

Head Office & Works: COOPER & CO., (Birmingham) LTD., Brynmawr, Breconshire.

Telephone: Brynmawr 312. Telegrams: Felting Brynmawr.

Registered Office & Works: Little King Street, Birmingham, 19.

hardening gear teeth



the "machine tool"
approach



BIRLEC automatic high frequency induction heating machines can be supplied for hardening the teeth of certain types of gear-wheels, greatly reducing distortion and surface defects.



Alternative methods provide for hardening:—
 (a) the complete tooth
 (b) the tooth contour
 (c) the flanks and root only.

The installation may be placed directly in the machine line and gives rapid, uniform production without skilled operation.

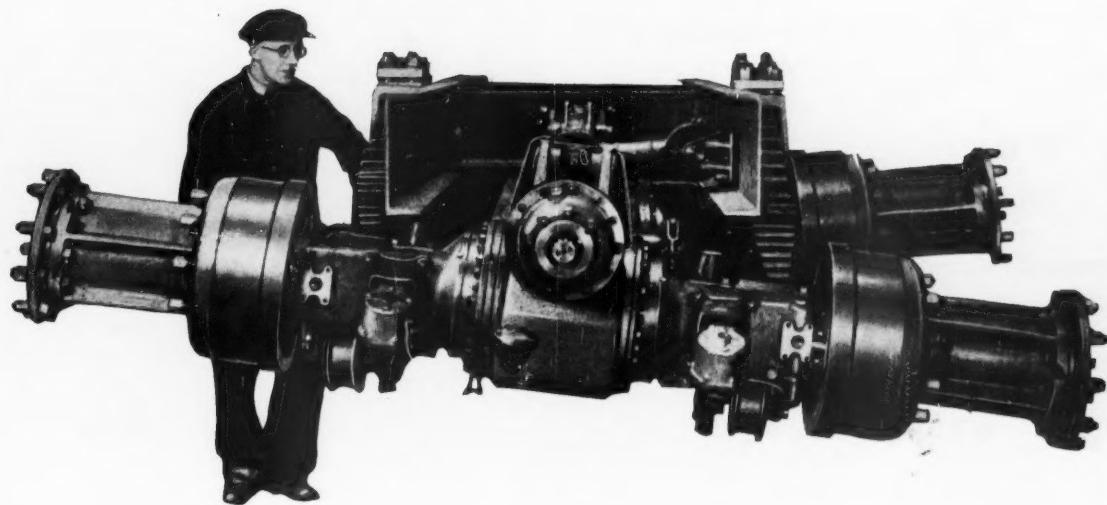


sm/b.926.53a

BIRLEC LIMITED
ERDINGTON · BIRMINGHAM 24

Sales and service offices in LONDON, SHEFFIELD and GLASGOW

KIRKSTALL AXLES



A GIANT KIRKSTALL BOGIE

GROSS VEHICLE WEIGHT 85 TONS TWIN 14" TYRES

WEIGHT ON BOGIE TYRES 35 TONS OVERALL WIDTH 10' 3"

**KIRKSTALL FORGE ENGINEERING LTD
LEEDS**

Telephone: Horsforth 2821

What stands behind him?

The man in the shop . . . like this operator using a hardfacing electrode . . . can only produce good work if you give him the latest information (and the proper tools) with which to do the job. **WELDING & METAL FABRICATION**, founded in 1933, is the journal covering all aspects of fabrication—from forming and shaping to final assembly. Its information keeps you in touch with the newest developments in fabrication, plant, processes and techniques. Send your subscription (33s. 6d.) to Dorset House, Stamford St., London, S.E.1, or write for a specimen copy.

Keep up-to-the-minute with

**Welding and
Metal Fabrication**



INDUSTRIAL FURNACES Electric OVENS

Funditor Electric Furnaces are used for the efficient melting of any metal up to a temperature of 600 C.

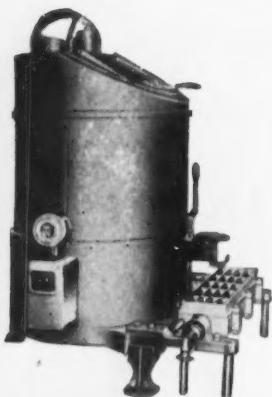
Heavy-duty elements around the crucible give uniform heat distribution. Correct heating, within fine tolerances, assured by Automatic Temperature Control.

Efficiency combined with complete safety results in maintenance of accurate melting points and subsequently perfect casting.

Funditor Electric Ovens assure maximum thermal efficiency, and Automatic Temperature Control, for all heat processing up to a temperature of 450 C.

Forced air circulation can reduce certain process times by 50%, or natural circulation may be employed.

Ovens designed to permit wide variation of the standard range to suit individual temperature and capacity requirements.



a good job—it's FUNDITOR!

Send for
Technical
Literature

Funditor Ltd

3, WOODBRIDGE STREET, LONDON, E.C.1

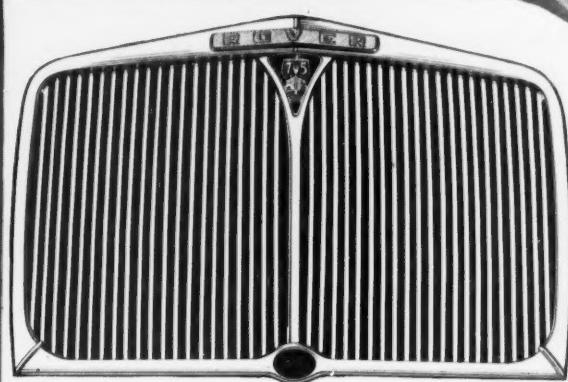
CLErkenwell 6155/7

RE-METALLING • BABBITTING • SOLDERING
TINNING • DIPPING • ETC.

CURING • DRYING
BAKING • PRE-HEATING • ETC.



British-built in Birmabright . . .



The radiator grille of the Rover 75 is in anodised Birmabright BB2 and is made by J. Fray Ltd. The doors, bonnet and trunk lid are made in BB3 by the Pressed Steel Company Ltd.

Bring us *your* problems. Our Technical Department will gladly advise you in the use of aluminium for your particular needs.

LIGHTER...STRONGER...NEVER-RUSTING

Birmabright

Registered Trade Mark

The Pioneer Aluminium-Magnesium Alloy

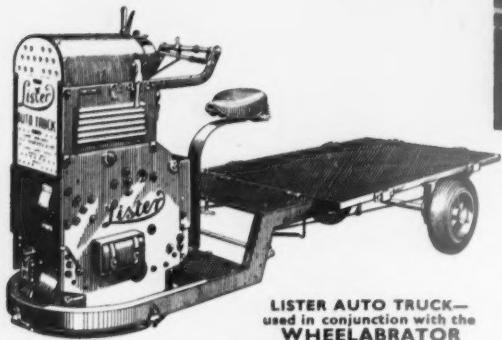
BIRMA BRIGHT LIMITED • BIRMINGHAM 32 • BIRMETALS LIMITED

BMII

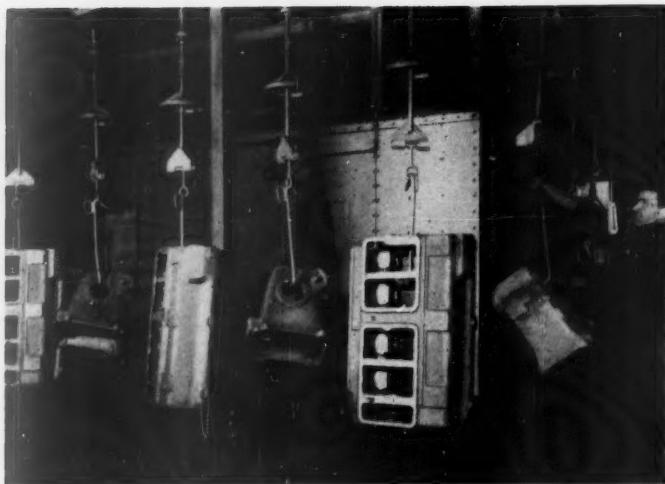
TILGHMANS WHEELABRATOR

Reg'd. Trade Mark.

on production work at
R. A. LISTER & CO. LTD.
DURSLEY



LISTER AUTO TRUCK—
used in conjunction with the
WHEELABRATOR



The plant illustrated above has a chamber 22ft. x 9ft. x 8ft. 6ins. and is equipped with three 19½in. diameter Wheelablator Units. The rate of travel of the conveyor can be varied between 6ft. and 12ft. per minute and it is capable of carrying 600lb. on each hook. Note the bright, clean finish of the components.

Let us solve **YOUR** cleaning problems !!

TILGHMAN'S PATENT SAND BLAST CO. LTD. BROADHEATH, NEAR MANCHESTER, ENGLAND.

LONDON OFFICE: BRETTENHAM HOUSE, Lancaster Place, Strand, W.C.2
Telephone: ALTRINCHAM 4242/7

AGENTS:
MIDLANDS: R.J. Richardson & Sons Ltd., Commercial Street, BIRMINGHAM.
SCOTLAND: Balbardie Ltd., 110, Hanover Street, EDINBURGH.

W 22



*"Did not obstruction's vessel hem it in,
Force were not force; would spill itself in vain . . ."*

Francis Thompson

Resistance is the necessary complement of force.

On that principle is based the effectiveness of steam, hydraulic and electrical power, as also the shaping and compacting of metal to toughened fibre, as in the production of a Drop Forging.

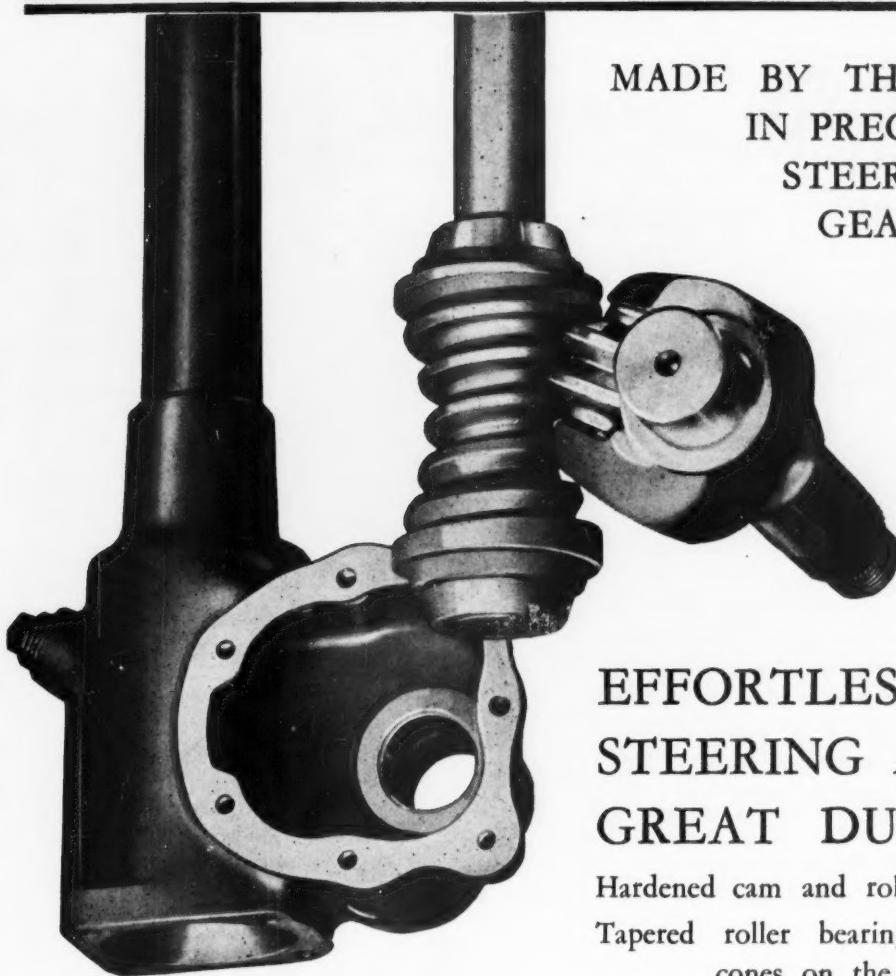
This same law also rules in human affairs. The character of an individual or firm can be shaped and strengthened by utilising obstructions and difficulties as essential components to achievement.

S.W.F
PRESS & DROP FORGINGS

SOUTH WALES FORGECASTERS LTD
GARTH WORKS • TAFFS WELL • CARDIFF

Gram: FORGECASTERS TAFFS WELL Phone: TAFFS WELL 61/2





MADE BY THE PIONEERS
IN PRECISION
STEERING
GEARS

EFFORTLESS
STEERING AND
GREAT DURABILITY

Hardened cam and roller.

Tapered roller bearings (with detachable cones on the larger sizes).

Double bearing support to rocker shaft.

End-location adjustable.

Larger angular movement.

Very compact box.

For fore-and-aft or transverse layout.

Trunnion or spigot mounting alternative on heavy types.

THE 'MARLES'
DOUBLE-ROLLER
GEAR, made in a
range of sizes
covering every type
of chassis.

M A R L E S

ADAMANT

ENGINEERING CO. LTD., DALLOW ROAD, LUTON
Sole proprietors of the Marles Steering Company Ltd.
Telephone: LUTON 2662 (4 lines). Telegrams: ADAMANT, PHONE, LUTON



OSBORN

**ENGINEERS'
CUTTING TOOLS
IN
"DOUBLE MUSHET"
HIGH SPEED STEEL**

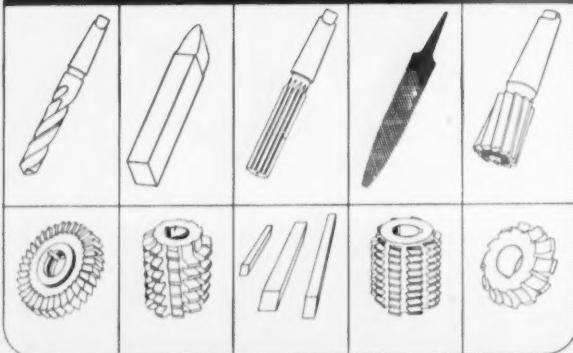
Because of their consistently high standard of accuracy and performance, "Mushet" Brands of Engineers' Cutting Tools, made from the famous series of "Mushet" high speed steels, are renowned wherever engineering takes place.

The Osborn range of Engineers' Cutting Tools covers every machining operation—fine tools backed by generations of experience.

For long life and better production specify—

"DOUBLE MUSHET" TOOLS

OTHER TOOLS MANUFACTURED



**SAMUEL OSBORN & CO., LIMITED
CLYDE STEEL WORKS · SHEFFIELD**

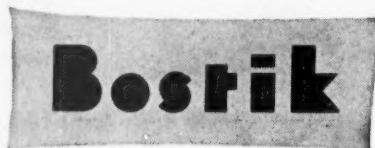
**ADHESION AND SEALING POINTS IN CAR
MANUFACTURE**



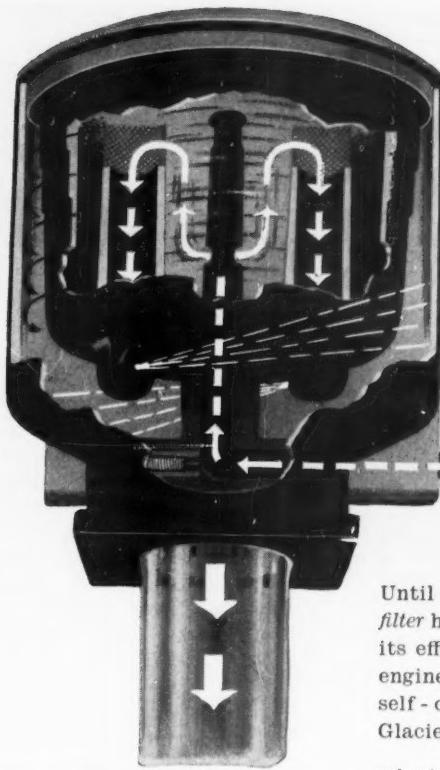
**... there's a job for
Bostik**

The efficient fixing of anti-drum pads in modern cars can be done—and is done—with 'Bostik' Adhesive. It is by far the fastest, cheapest, and most efficient way of doing this simple but essential job. Indeed, for faster, cheaper, and more efficient methods in every branch of car manufacture today, ALL British car manufacturers employ 'Bostik' Adhesive, 'Prestik' Sealing Strip and 'Bostik' Sealing Compounds. Remember . . .

**for every sticking and sealing job in the
Motor Industry there's a job for**



The word "Bostik" is a registered trade mark of
B.B.CHEMICAL CO. LTD., ULVERS CROFT ROAD, LEICESTER.



What,

another filter?

No—a revolution!

FOOLPROOF EFFICIENCY—NO ELEMENTS TO REPLACE

Until now, to users of road vehicles and stationary engines, an oil filter has always meant an oil strainer. Centrifugal separation, though its efficiency was known, has never been generally available to the engine-building industry. Now it is here, in the form of a compact, self-operating component. And the advantages now offered by the Glacier Centrifugal Oil Filter are so many that they cannot be ignored.

valve into play which feeds dirty oil to the bearings. The Glacier Centrifugal Oil Filter maintains high efficiency and constant flow.

THE TEST OF £.s.d.

With filters of the strainer type, the relatively frequent cleaning or replacement of the strainer element is imperative. A fleet of vehicles can run up a pretty bill in a year on new elements alone. There is nothing to replace in a Glacier Filter. There are no running costs. Inspection and cleaning can be carried out in five minutes. The filter component, as you buy it, should last the life of the engine without any trouble or replacement of parts: it is designed for engines of 60/120 b.h.p., but larger models, and also a smaller model specifically designed for motor cars, are under development.



ADD THESE ADVANTAGES UP

1. Higher efficiency.
2. Constant flow.
3. No replacement elements.
4. No clogging.
5. Sump filtered every few minutes.
6. Dirt capacity many times greater.
7. Easy inspection and easy cleaning.
8. Easy fitting with Glacier accessories — no independent drive required.
9. A precision-engineering job which cannot go wrong.

That's the **GLACIER** CENTRIFUGAL OIL FILTER

REGD. TRADE MARK

—sooner or later you'll fit it

THE GLACIER METAL COMPANY LIMITED, ALPERTON, WEMBLEY, MIDDLESEX



introduce
TWO NEW
Visible FILTERS!



**20/-
RETAIL**

**B.1681 VISIBLE
FILTER
FOR COMMERCIAL
VEHICLES**

A line filter with a $\frac{1}{2}$ " B.S.F. $\times \frac{1}{2}$ " long stud fixing at the top for fitting to a bulk-head, with a bracket which is supplied with each unit.

Ref.	Pipe Size	Union Type
B1681A	$\frac{1}{2}$ "	Solderless
B1681B	$\frac{1}{2}$ "	Soldered

**1124 VISIBLE
FILTER
FOR VEHICLES &
STATIONARY
ENGINES**

A line filter with a fixing lug with hole for $\frac{1}{2}$ " bolt.

Ref.	Pipe Size	Union Type
1124A	$\frac{1}{2}$ " O.D.	Solderless
1124B	$\frac{1}{2}$ " O.D.	Solderless
1124C	$\frac{1}{2}$ " O.D.	Soldered
1124D	$\frac{1}{2}$ " O.D.	Soldered

*Keep out
the dirt—
Keep on going!*

*Order through your local garage, but if you have
any difficulty, contact the manufacturers.—*

**BENTON & STONE LTD., ASTON BROOK STREET
BIRMINGHAM 6**

Constant Economy



B.T.G. Patented Constant Helix cutters represent an important advance in manufacturing technique and will cut your costs in all profiling, die sinking, mould milling and reaming applications. Milled with a flute lead which varies in direct proportion to the diameter, the helix angle of the teeth remains constant throughout the length of the cutter. This gives better shearing action, minimum deflection, increased end-on loads and permits easier resharpening.

For faster cutting under better conditions B.T.G. Constant Helix cutters are unequalled.

We welcome enquiries for single numbers or large quantities.

CONVENTIONAL TAPER

Note that the helix angle is entirely dependent upon cutter diameter, the fixed lead resulting in a lying down effect on small end with heavy bending moment from shank. Absence of generous shear on extreme end steps up milling power requirements and increases torsion on cutter.



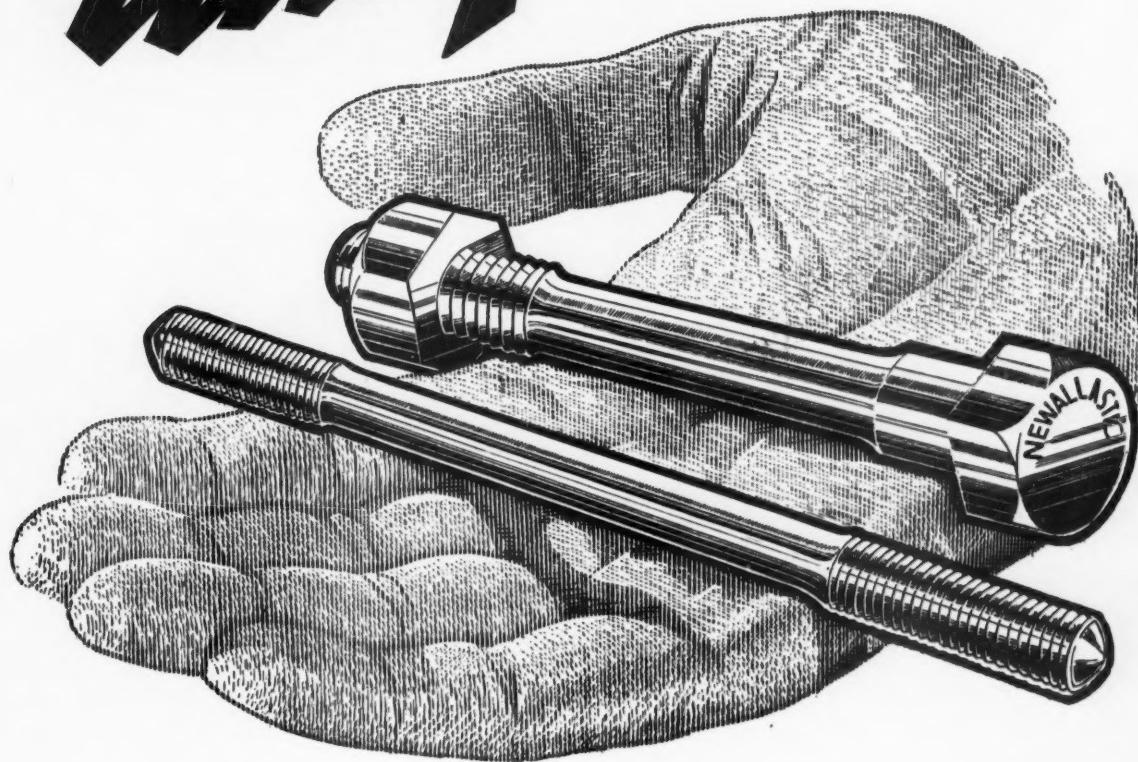
CONSTANT HELIX. In this case the lead is directly proportional to the diameters, with good shearing conditions on the extreme end and bending moment reduced and replaced with better end-on loads, making for steadier, vibration-free cutting and increased rates of stock removal.



British and Foreign Patents
Granted and Pending

BIRMINGHAM TOOL & GAUGE CO LTD. BIRMINGHAM 19

Unique



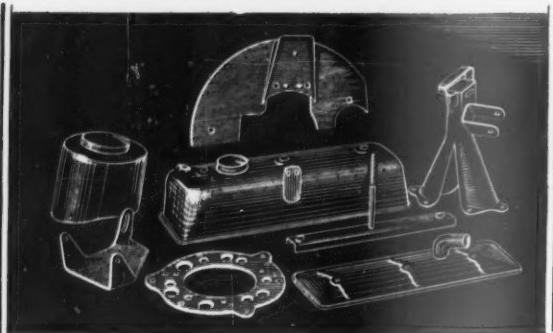
"Newallastic" bolts and studs have qualities which are absolutely unique.

They have been tested by every known device, and have been proved to be stronger and more resistant to fatigue than bolts or studs made by the usual method.

A.P. Newall & Co., Ltd.
POSSIL PARK GLASGOW • N



★ OF ALL TYPES



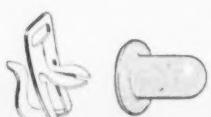
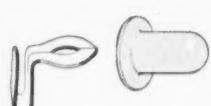
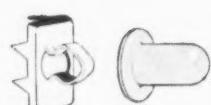
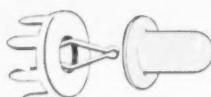
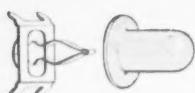
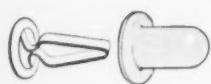
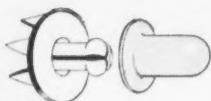
★ IN ALL METALS

As specialists in the production of precision pressings for the leading automobile and commercial motor manufacturers we are well equipped to handle all your requirements.

A.E.JENKS & CATTELL
limited

PHOENIX WORKS • WEDNESFIELD
WOLVERHAMPTON

1445/B



**Twin bogies
conquered
at last!**

DUST AND WATER ENTRY has for long been a major problem for all Body Engineers. Extensive study and experiment has convinced us that it cannot be solved by metal formation only. With the aid of our Plastics factory we have at last found the solution in our "Snap Sacs" (patent applied for).

They can be used with any of our Snap-in Fasteners, already in extensive use in the trade, thus obviating any major change. "Snap Sacs" are sold with the fasteners. Low in cost—Easy to apply—Satisfactory in use. A slightly larger hole is all that is required for fitting.

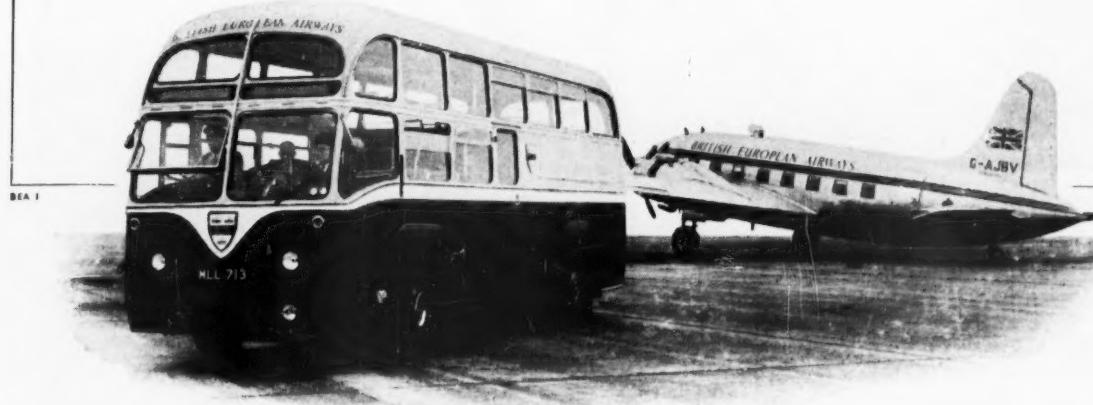
A generous supply of experimental samples is waiting for you.

CARR FASTENER CO. LTD.
Stapleford, Nottingham.
Telephone: Sandiacre 2234.

Also at: London,
Manchester,
Birmingham



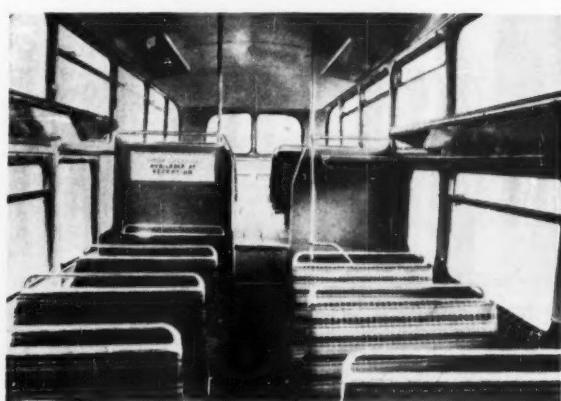
B.E.A. passengers ride with **JAMES BOOTH ALLOYS** in Coach and Aircraft



As passengers step from the aircraft and board this new B.E.A. coach, they see James Booth light alloys used in two forms of transport. In the B.E.A. coach, Park Royal Vehicles Ltd. have used 'MG7' in the body construction,

taking advantage of the fact that it is non-rusting, pleasant to the touch and easy to fabricate.

'MG7' is one of a range of alloys manufactured by James Booth & Co. Ltd., which are widely used in the construction of road vehicles of all descriptions. The saving of weight cuts down fuel consumption and tyre wear, making a considerable reduction in operating costs. The strength and resilience of the materials enables a vehicle to give longer trouble-free service.



JAMES BOOTH & COMPANY LIMITED
ARGYLE STREET WORKS · BIRMINGHAM 7

Like B.O.A.C.*



Get
paint
spray
protection

TAPED

AUSTIN, B.S.A., B.O.A.C. are three great names in this mechanical age. Producing the best, they use the best—and they all use Permacel. Permacel Crepe Paper Masking Tape is used by all three for masking chromium, windows or other surfaces during paint spraying. B.S.A. and Austin also use Permacel Cloth Tape for every job which requires protection against knocks and scratches. There is a Permacel Tape for every job which requires protection during transit, or masking before painting.

Permacel Tape sticks firmly and at once to any surface, rough or smooth. It is skin-flexible to cover the most awkward contours, and when the time comes for removal it peels away easily and cleanly.

Permacel Crepe Paper Masking Tape is 'double-bonded'. This exclusive Johnson & Johnson process permanently bonds the adhesive to the backing material. When stripped away the tape leaves no sticky trace.

A V.I.P. YOU SHOULD KNOW! A Very Important Point about all Permacel Masking Tape—it's unaffected by paint, chemicals or dope solvents!

with

Permacel

CLOTH AND 'DOUBLE-BONDED'
CREPE PAPER MASKING TAPES

TRADE
MARK

Johnson & Johnson
(GT BRITAIN) LTD
SLOUGH, BUCKS

For samples and quotations write to:
INDUSTRIAL DIVISION Dept. A.E.

The drill for more production



Engineers in the
motor industry, like
their counterparts in
other branches of
engineering, know that
the best work can only
be turned out if they
use the best tools. That
is why they always
ask for INTAL tools.

**Drills • Reamers
Milling Cutters
Ground Thread Taps**

Obtainable
from your
stockist

Intal

**That's
the
DRILL**

THE INTERNATIONAL TWIST DRILL COMPANY LTD
INTAL WORKS, WATERY STREET, SHEFFIELD, 3

Telephone: Sheffield 23072-3-4 Telegrams: "Fluted, Sheffield 3"



Albert is a Master of the Rolls!

Public records? No—but the rolls that owe their quality to Albert Hopkinson are no less important in their way. For Albert is a master

of the cold rolling of steel strip—a sturdy art that demands the highest degree of skill and dexterity. Into every minute that he works, Albert concentrates a lifetime's learning. He knows that on his knowledge and experience depend the safety and efficiency of the world-wide applications of Habershon Steel Strip.

For well over a century we have manufactured hot and cold rolled strip, sheets and sections (maximum width 32", minimum thickness .0015") to all specifications and for all purposes. Your enquiries are invited.

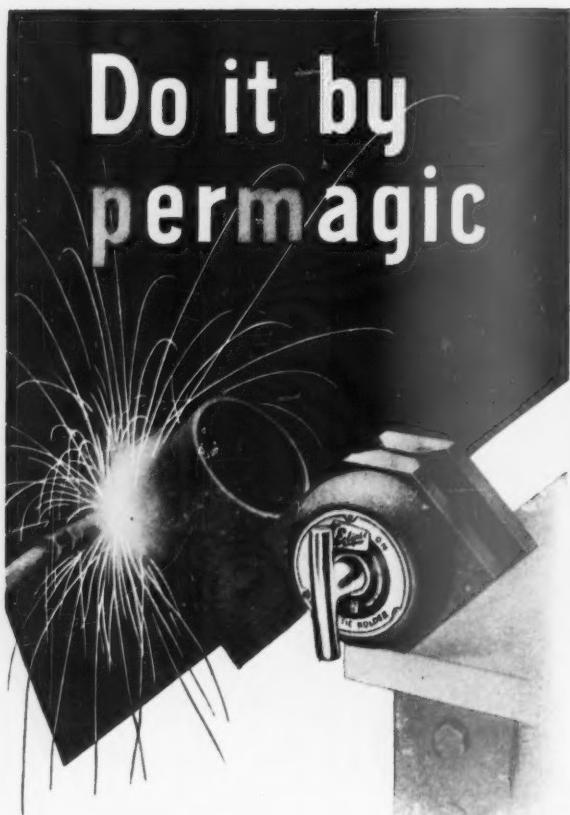
Habershon STEEL STRIP

meets the most *exacting* requirements

J. J. Habershon & Sons Ltd., Rotherham. Telephone 2081 (6 lines)



Do it by permagic



Magnetic Holder . . .

* Saving hours of useless jiggling time and providing by a simple turn of a handle a second pair of hands for every plumber and welder. Suitable for use in connection with all classes of welding, and designed by the makers of the world-famous "Eclipse" permanent magnet chuck, this tool pays for itself many times over. Ask for full details and illustrations of its uses in toolrooms and welding shops in Publication P.M.118/53.

Supplies through appointed
"Eclipse" Distributors



**Magnetic devices designed
to accelerate production**

JAMES NEILL & CO. (SHEFFIELD) LTD., ENGLAND.

PMB



To make more space for a passenger's knees steal a bit of space from beneath him. With Intalok Spring Cases you can make the seats shallower without losing any comfort. *Intalok Spring Cases are used today by many British car manufacturers.*

INTALOK SPRING CASES FOR CARS

A PRODUCT OF THE SLUMBERLAND GROUP. TRADE ENQUIRIES TO:
INTALOK LTD., CALDWELL ROAD, NUNEATON. TEL. NUNEATON 2367/8



Specially blended to give
MAXIMUM
ENGINE PERFORMANCE



CLEVECOL SPECIAL is blended to produce the highest engine performance—greater power, more mileage, faster and smoother acceleration, and a lot more pleasure in driving! Clevecol Special is far superior to any petrol previously marketed.

The Super quality Petrol distributed by

CLEVELAND
THE SPECIALISTS IN
MOTOR SPIRITS

CLEVELAND BENZOLE MIXTURE
is a most excellent blend for smooth running and extra miles per gallon.

CLEVELAND GUARANTEED
the well-known general purpose spirit is superb value for engines which do not demand a premium grade.

The BIG UNIT for the BIG JOB!

NEWTON
TRADE PRODUCT MARK
REGISTERED

**SUPER
HEAVY
DUTY
UNIT**

★
**STANDARD
EQUIPMENT**

on the
majority of

**BRITISH
PASSENGER
CARRYING
VEHICLES**



Service
and
maintenance
instructions
available to

P.S.V. OPERATORS

Send for
Brochure No. 226/I

NEWTON & BENNETT LTD
VALETTA ROAD ACTON LONDON NW3

Telephone: Shepherds Bush 3443 (4 lines) Telegrams: Newsorber, Eolux, London

**AS PLASTICIANS
WE'RE
MAGICIANS!**

*When motor car makers
Survey their 'broad acres'
And look at the jobs on the band,
It's simply fantastic
How mouldings in plastic
Will speed up the work that's on hand.*

*Accessories, too,
Come under review;
Here plastics can help quite a lot.
If you make or supply
It's important to cry
"What it takes is what EKCO have got!"*

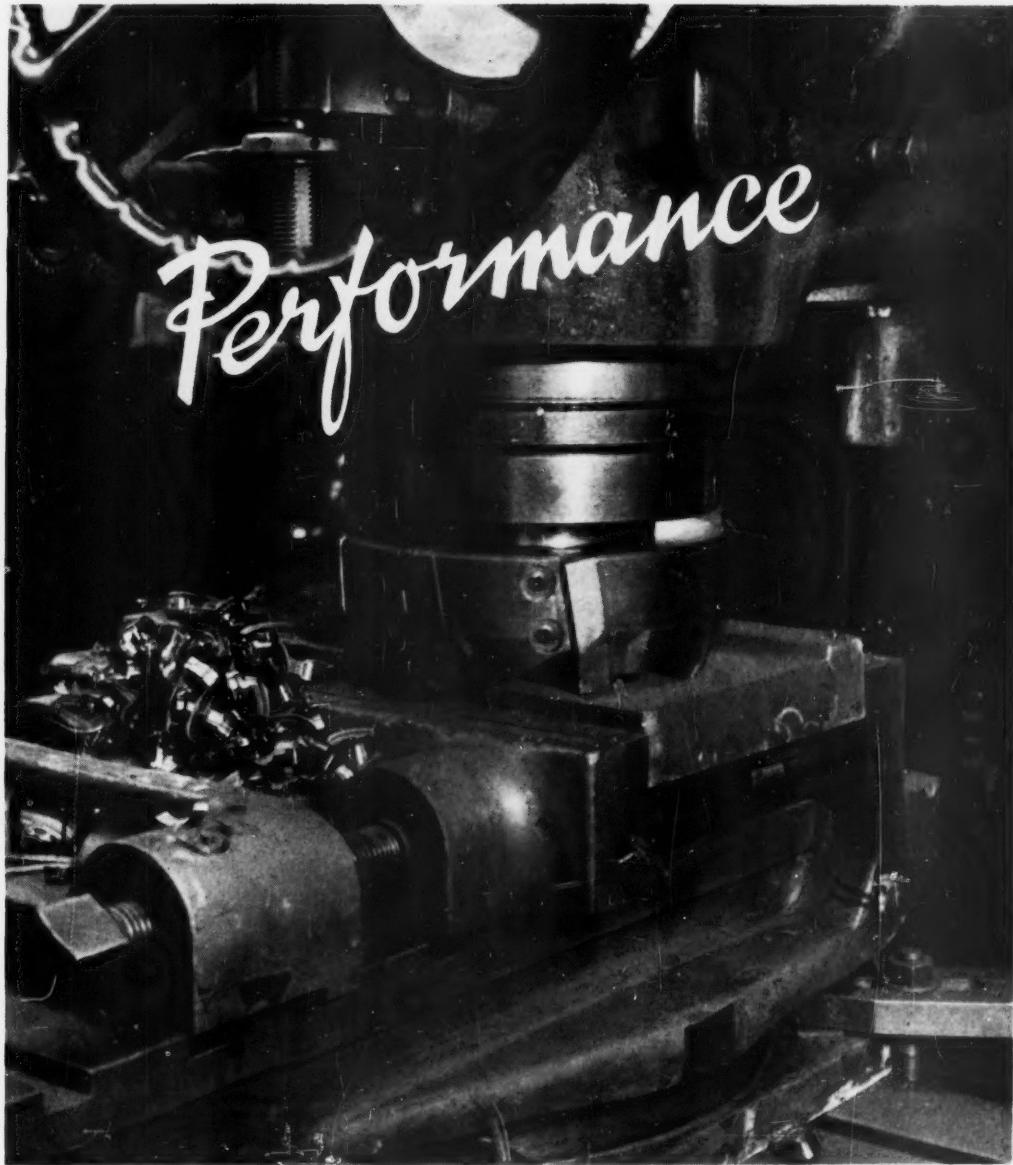
*For dashboards and dials
And wing ornament styles
EKCO do tooling and moulding.
With switches and knobs
And much bigger jobs
They keep the production
lines rolling.*

*State the plastics position
Re lamps or ignition,
They'll be only too pleased
to advise.
There's no moulding problem
That's likely to fog them
Or cause them the
slightest surprise.*



EKCO
PLASTICS

Send for our fully illustrated brochure "Plastics for Industry"
E. K. COLE LTD., SOUTHERN ON SEA, ESSEX
(Members of the British Plastics Federation)



The photograph shows a heavy cut being taken on a steel die plate by a milling cutter of inserted-tooth type. The teeth, with double negative rake, are of Cutanit Grade S. which is highly reputed for such work.

For Maximum Performance

Cut with 
Cutanit
TRADE MARK
CEMENTED CARBIDE
A METRO-CUTANIT PRODUCT

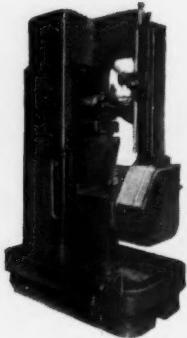
WM JESSOP & SONS LTD BRIGHTSIDE WORKS SHEFFIELD	 <i>THE SIGN OF QUALITY</i>	J J SAVILLE & CO LTD TRIUMPH WORKS SHEFFIELD
---	---	--

GEAR TOOTH PRODUCTION



This automobile main shaft gear has 27 teeth, 9.25 N.D.P., Helix Angle 26°—13'—15" Right Hand, $\frac{1}{4}$ " gear face width. The material was EN 35A tensile strength 40 tons per sq. in. Cutting time (rough hobbing) was 6.5 minutes for two components per cycle.

Hobbing



Use of the Automatic Shifting Hob Head permitted the machining of 200 components before the hob required regrinding. Feed was .050" per rev. of work, climb hobbing. Hob speed 110 r.p.m., double start hob. Floor to floor time 7.3 minutes (2 components).

CHARLES
CHURCHILL
& CO. LTD.

COVENTRY ROAD · SOUTH YARDLEY · BIRMINGHAM, 25
ALSO AT LONDON, MANCHESTER, GLASGOW AND NEWCASTLE-ON-TYNE

CHURCHILL CLEVELAND RIGID HOBBER MODEL S-8-15

AMAL

Component Specialists to the Motor Industry

AMAL LTD · HOLDFORD ROAD · WITTON · BIRMINGHAM 6



In thirty years and more we have designed and made a lot of springs—good springs from the best materials available. Now we feel we really have springs at our fingertips, and there isn't much we don't know about them. Don't you think all that experience would be useful to you?

Est. 1919. A.I.D. approved

THE LEWIS SPRING CO. LTD.
(Springs, Spring Clips, Presswork, Wire Forms).
RESILIENT WORKS, REDDITCH.

Telephone: Redditch 72012

LONDON OFFICE:
321 HIGH HOLBORN, W.C.1 Telephone: Holborn 7479 & 7470

LEAVE IT TO
Lewis
OF REDDITCH

THESE ARE OUR PRODUCTS

No.3

**machine screws
and bolts**

Manufactured in a range of sizes from 8 B.A. to $\frac{5}{16}$ in. diameter, we produce a variety of types of thread to all British, Unified and Metric standards. Extreme accuracy of effective diameter, pitch and thread form, the essentials of any good screw or bolt, are assured by up-to-the-minute Linread tool-making technique and the use of *quality control* in inspection at every stage of manufacture. Consequently interchangeability and ease of assembly are certain. Linread Machine Screws and Bolts are obtainable in various materials such as mild steel, brass, light alloy and high tensile steel.

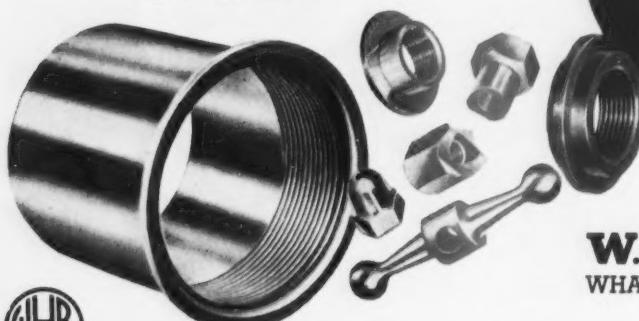
As with all Linread products, their manufacture is backed by the resources of the Linread organisation and the experience of its experts, who are always available to be of service to you.

Linread

LINREAD LTD · COX ST · BIRMINGHAM 3

**PRESSINGS
TURNED PARTS
ASSEMBLIES**

in ferrous or non-ferrous metals,
electro or enamel finishes for the
Automobile Industry and the General
Engineering Trades.



Component parts or complete assemblies designed and produced to the customer's requirements.

Our technical staff will be pleased to advise.

W.H.BRISCOE & CO. LTD.
WHARFDALE ROAD, TYSELEY, BIRMINGHAM 11

Telephone: ACOcks Green 1197
Telegrams: "Brisk, Birmingham."

Holden

For reliability
PERRY
TIMING CHAINS

are fitted to the new

STANDARD
EIGHT



PERRY CHAIN COMPANY LTD., TYSELEY, BIRMINGHAM

*Ignore this,
and it may
cost you money!*



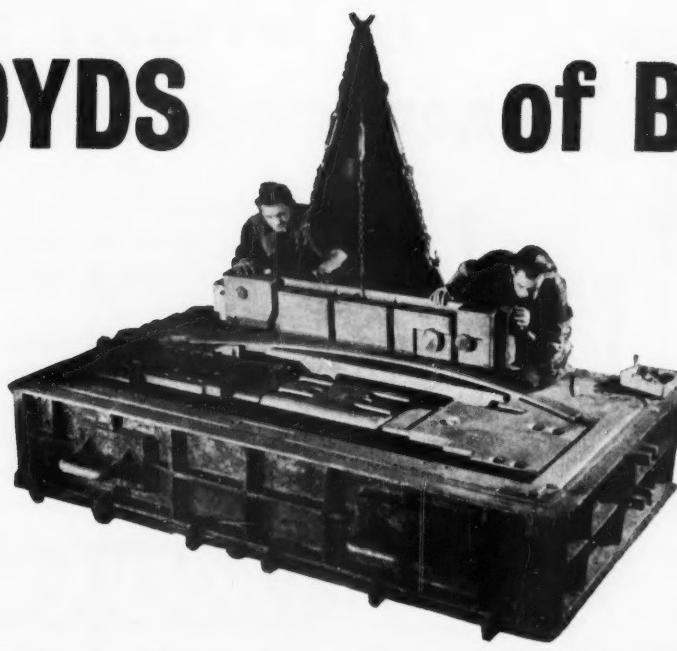
Faulty ignition, indifferent lighting, inefficient charging, all cause delay and consequent loss of money. At the first sign of any of these danger signals, do the wise thing, have your truck rewired with AERIALITE, the Safe, Dependable Auto Cable.

AERIALITE LTD., STALYBRIDGE, Cheshire



AERIALITE
THE
Safe, Dependable
AUTO CABLE

LLOYDS of Burton

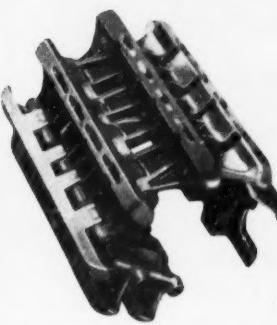
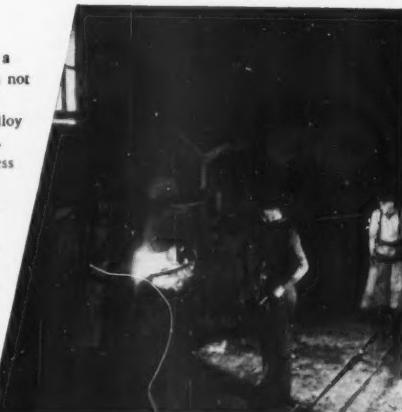
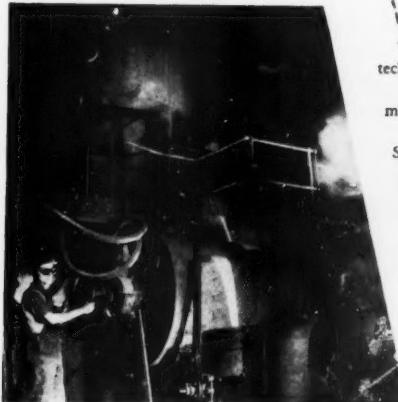


are casting Alloy Steels and High Duty Irons

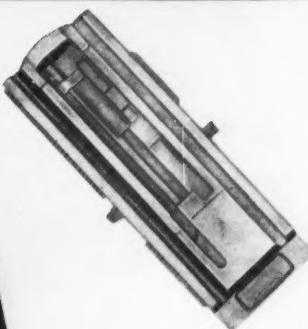
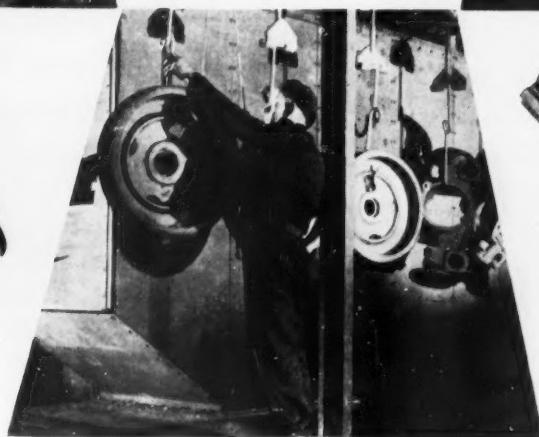
Including Manganese Steel

Including Ductile Iron

The successful casting of Manganese Steel calls for a technical knowledge and degree of practical application not commonly found in the foundry field. Yet manganese steel is only one of the wide range of alloy and carbon steels that are cast by Lloyds of Burton. Similarly, the making of Ductile Iron is a process demanding the strictest and most experienced metallurgical and melting control, but Lloyds cast Ductile Iron with the skill and sureness with which they cast a wide range of High Duty Irons. Complete quality control of every process gives Lloyds castings a uniform structure, which ensures easy machining, exceptional durability and optimum efficiency. Whatever your requirements in the Ferrous foundry field consult Lloyds of Burton before you order.



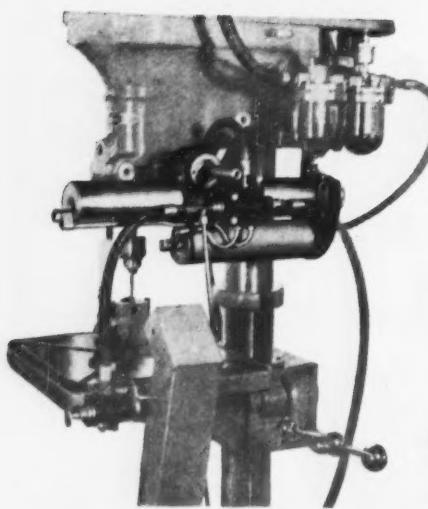
Manganese Steel Centurion Tank
Track Links approximate weight of
each link 38 lbs.



Ductile Iron Slide Casting for
Machine Tools approximate weight
200 lbs.

LLOYDS (BURTON) LTD., WELLINGTON WORKS, BURTON-ON-TRENT. TELEPHONE: BURTON 3867

A Print for Industry Ltd. Advertisement



OF INTEREST TO PRODUCTION ENGINEERS

? Can you convert standard drilling machines to automatic operation and obtain very considerable increase in production.

? Can you secure this increase with small capital expenditure.

? Can you maintain regular and continuous production using unskilled operators and eliminate operator fatigue.

Why not arrange for a
DEMONSTRATION
on your own Components
at our Slough Works
TEL: SLOUGH 22396.

Definitely Yes!

WITH THE

PACERA MAXAM

AIR HYDRAULIC POWER
FEED UNITS

SEND FOR INTERESTING DETAILS

Rathbone

W. J. MEDDINGS LIMITED

16 Berkeley Street, London, W.I. • MAYfair 6417

Send for this folder



If you use Drop Forgings, this folder will interest you. Leading manufacturing concerns use Mitre precision Drop Forgings in order to maintain quality and keep production costs down to the minimum.

A. J. VAUGHAN & CO (MITRE WORKS) LTD
WOLVERHAMPTON ROAD, WILLENHALL, Staffs. Phone 4867.

C.T.D.

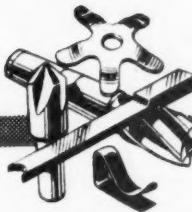
(BIRMINGHAM) LIMITED
MIDland 0553

DESIGNERS OF:

**MOTOR BODY
PRESS TOOLS &
ASSEMBLY JIGS**

SINGLE & DOUBLE ACTION
DRAW DIES • RAISE, FLANGE &
WEDGE ACTION DIES • FORM,
CURL & BRAKE TOOLS • SUB-
ASSEMBLY JIGS & MAIN BODY
BUILD JIGS

SHAFESBURY BUILDINGS • STATION STREET • BIRMINGHAM 5



PAN CONVEYOR FURNACE

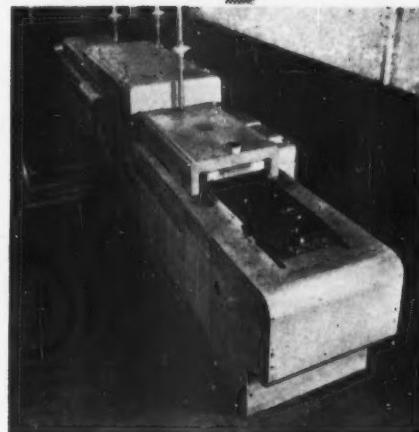
The pan conveyor furnace illustrated is used for hardening small components which are placed on pans fitted together by chain links, the components passing through the water cooled zone into the heating chamber and are then automatically plunged into the quench tank.

The heating chamber is 5 foot long and has a cross section of 20" x 6" high, built of refractory material with specially shaped hard bricks to support the large diameter nickel-chromium tubular elements placed in the roof and hearth. The quench chute is also provided with elements.

The top part of the furnace chamber is removable allowing access to the heating elements, conveyor and floor tray. The quench opening is provided with a downward extension for sealing into the quench tank and is fitted with a gas union for feeding gas to the interior of the chamber.

The heating chamber is split into two zones and has a maximum operating temperature of 900—950°C.

The coolers each end of the heating chamber are features which make Wild-Barfield Pan Conveyor Furnaces very efficient. The cooler at the exit end is for cooling the work trays in an atmosphere to avoid scaling which would be detrimental to the finish of the work, as during heating they would give off oxygen from their scale which would attack the work. A further function of this cooler and the one at the entry end is to give a satisfactory balance of atmosphere in the furnace, by contracting the gas before it leaks out at the ends.



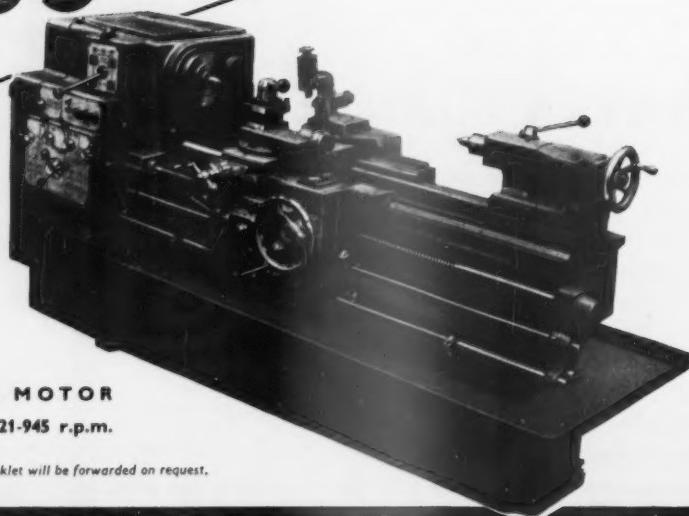
WILD-BARFIELD ELECTRIC FURNACES

for all heat-treatment purposes

WILD-BARFIELD ELECTRIC FURNACES LTD.
Watford-by-pass, Watford, Herts. Phone: Watford 6091 (6 lines)

wm
85

8½" CENTRE LATHE



10 H.P. MOTOR
SPEEDS 21-945 r.p.m.

Illustrated booklet will be forwarded on request.

Designed and built for sustained production at high speeds, the new W & M 8½" lathe has set a new high standard of performance and reliability. Specification includes:

- Rigid diagonal braced bed with additional stiffness provided by one piece fabricated steel base.

- Rapid selection of spindle speed with clear indication of desired speed.

- Totally enclosed auto lubricated quick change feed gear box with provision for metric module, diametrical, and fractional pitch thread cutting without recourse to multiplicity of change wheels.

- Totally enclosed auto lubricated apron with single lever selection of desired feed motion with choice of coarse or fine to each motion.

- Large direct reading dials to feed screws.

WOODHOUSE & MITCHELL

PROPRIETORS · THOS. W. WARD LTD.

PHONE: BRIGHOUSE 627 (3 Lines) · WAKEFIELD RD. · BRIGHOUSE · GRAMS' WOODHOUSE, BRIGHOUSE -

WM/11



Cary springs, made for all types of road vehicles—from the private car to the heavy lorry—are of the highest quality and incorporate the skill and experience of over 100 years of spring making.

For the quantity production of coil springs for car suspension a modern factory has been equipped with facilities of the latest type including centreless grinding shot peening and crack detection.



WILLIAM E. CARY LTD.

RED BANK · MANCHESTER

Telephone: DEAnsgate 7881 (10 lines).

Telegrams: Carybank, Manchester

Also at
SALFORD, GLASGOW, LONDON & COVENTRY

JN 300



"POP" is a Registered Trade Mark of the manufacturers
Geo. TUCKER EYELET Co. Ltd.

Walsall Road · BIRMINGHAM 22.

Consultants and Tool
Manufacturers:

AIRCRAFT MATERIALS LTD.,
Midland Road, London, N.W.1

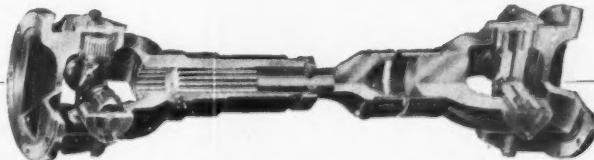
THE MODERN SYSTEM OF RIVETING





Desert Grit

The fleet of Thornycroft "Mighty Antars" used by the Iraq Petroleum Company to lay a pipeline to the Mediterranean Coast were fitted with Hardy Spicer propeller shafts and universal joints. To carry such immense loads over desert roads, travelling perpetually in a cloud of dust and grit, would tax the strength of the toughest vehicle. Hardy Spicer — specialists in motor transmission, have designed shafts and couplings which send racing cars hurtling round tracks at 150 m.p.h., drive coaches and lorries up mountain passes, and now, their latest achievement, to keep a fleet of heavily laden "Mighty Antars" rumbling across the desert.



PROPELLER SHAFTS AND UNIVERSAL JOINTS

HARDY SPICER LIMITED. (A Birfield Company), WITTON, BIRMINGHAM, 6
HARDY SPICER (AUSTRALIA) PTY. LIMITED, SOMERS STREET BURWOOD, E.13, VICTORIA, AUSTRALIA



"I rely on Charles Clifford for METAL"

NON-FERROUS METALS

Cold Rolled Sheet & Strip, Rods & Bars, Wire & Drawn Strip, Tubes, Chill Cast Bars, Phosphor Bronze, Gun Metal, Brass & Copper, Gilding Metal etc.



CHARLES CLIFFORD LIMITED

Dog Pool Mills, Birmingham 30
and
Fazeley St. Mills, Birmingham 5

Specialists in the production of Wrought High Tensile Alloys

M-W-360

Magnetic Chucks

In standard sizes or to your own specification. Our catalogue will help you select a type and size of chuck most suitable to your own needs. Write for your copy today.

J. H. HUMPHREYS & SONS
Blackriding Electrical Works, Werneth, Oldham
'Phone: MAIn 1651

FARNBORO' ELECTRIC INDICATOR

DOBBIE MCINNES

FARNBORO INDICATOR - COMBINED DIAGRAM.
800 lb./in. 600 400 200 E
A - CYLINDER POWER
B - CYLINDER NO FUEL
C - FUEL PRESSURE (d)
D - TDC LINE (Recorded)
E - PRESSURE (Recorded)

Large Diagrams up to 14½" x 7½"

No complex electric circuits. Replacements are negligible. No glass components. Simplicity ensures ready understanding and manipulation without special knowledge. Very large diagrams. No Photography, thus saving time and trouble. Calibration Lines can be recorded while taking Diagrams.



DOBBIE MCINNES LTD
Nautical & Engineering Instruments
BROOMLOAN RD. GLASGOW SW1

Also at SOUTH SHIELDS LIVERPOOL LONDON

FOR *Diecastings as strong as steel*

ALUMINIUM BRONZE CO. LTD.
Wallows Lane · Walsall · Staffs.

Telephone WALSALL 2108 (3 lines)
Telegrams "ABCO · WALSALL"

YOU EXPORT QUALITY, NOT RUST!

If you export machinery, tools or any other metal products nothing is more important than their arrival condition. Expense and trouble in producing a high grade finish are negated when goods are marred by rust or corrosion.

Wherever your metal goods are bound, abroad or at home, complete protection is afforded by the RODOL series of rust preventives. There are eighteen standard products and, between them, rust immunity is secured under most conditions of exposure, storage and use. This varies from brief inter-process protection to a guaranteed six months' life.

Protect it with

RODOL
RUST PREVENTIVES

FLETCHER MILLER

You are invited to avail yourself of the services of our technical department in any problem concerned with rust prevention or the overcoming of allied difficulties.

Sole Manufacturers:

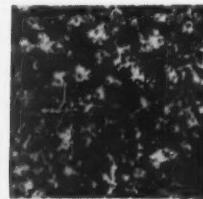
FLETCHER MILLER LTD., ALMA MILLS, HYDE, CHESHIRE. Branch Works at LONDON, WEST BROMWICH & GLASGOW

SEE HOW RODOL PROVIDES REAL PROTECTION AGAINST RUST

These enlarged photographs of mild steel plates after exposure to the standard Humidity Conditions Test demonstrate the relative degree of protection afforded by oil media in comparison with RODOL.



Heavy Petroleum Jelly—condition after 7 days, rust attack following original smear tracks.



Paraffin Oil—whole plate deeply rusted after 3 days.



Medium Heavy Mineral Oil—Heavy rust after 7 days exposure.



RODOL W.S.—completely rust-free after 180 days, although plate was rough emersed at outset to accelerate possible rusting.



and £4,000 damages

A press operator whose earnings are retarded by slow guard operation is a menace to himself and to you. He is tempted to expose himself to danger and may involve you in heavy damages. Fortunately, the 'Fastrip' Synchronised Guard ensures the highest standard of safety without impeding production. Send for full details to-day.

J. P. UDAL

INTERLOCK WORKS, COURT ROAD, BIRMINGHAM, 12
Telephone : CALthorpe 3114



CAROBRONZE

is the
**cheapest metal for high quality
Bearing Bushes because**

- high load capacity= shorter bushes
- excellent physical properties= thinner bushes
- small machining allowances= minimum wastage and labour

Your Designs Department should be interested in these qualities.

CAROBRONZE BRAND COLD DRAWN

PHOSPHOR BRONZE TUBING

CAROBRONZE LTD.
School Road,
Belmont Road,
London, W.4.

Telephone:
CHIswick 0245
Telegrams:
Carobronze-Chisk, London

MAVITTA DRAFTING MACHINES

A complete range of Drafting Machines for Boards up to 50 feet long, both vertical and horizontal.
Adjustable Drawing Stands and Boards.
Mathematical Scales in various materials.
Surveyor's Rods.
Isometric Projection Machines.



THE MASTER—latest in our range—Linkage by steel bands and pulleys—360 degrees rotation of index head—automatic location of main angles by press button through knob—quick release of head for lining up to drawings—counter balanced for vertical use—modern styling and high quality finish.

FULL CATALOGUE ON APPLICATION

The MAVITTA DRAFTING MACHINES LTD.

HIGHLANDS ROAD • SHIRLEY • BIRMINGHAM
Phone: SOLIHULL/2231/2. Grams: Mavitta, B'ham

AUCTIONEERS & VALUERS
OF
PLANT, MACHINERY
AND FACTORIES

SINCE 1807

**FULLER HORSEY
SONS & CASSELL**

10, LLOYD'S AVENUE · LONDON · E.C.3. Phone ROYAL 4861

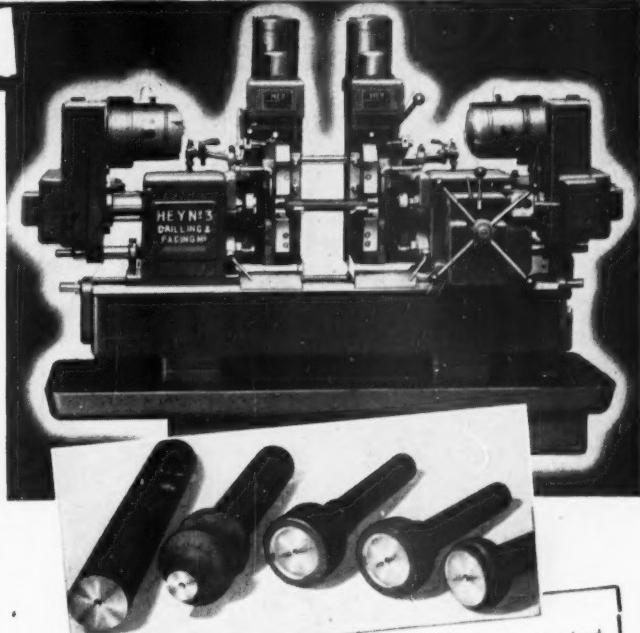
Rathbone

130 SHAFTS FACED AND CENTRED PER HOUR.

Facing $\frac{1}{8}$ " off each end and drilling $\frac{7}{16}$ " centres in $2\frac{1}{2}$ " diameter Electric Motor Shafts in a floor to floor time of 27 seconds, is typical of the high production which can be achieved on the—

HEY NO. 3 DOUBLE ENDED CENTRING AND FACING MACHINE

- Perfect alignment of centres.
- True faces and accurate lengths.
- Turned finish on faces.
- Eliminates subsequent facing down to centres or recentring.



We also manufacture Rotary Cam and Profile Milling Machines, Short Thread Milling Machines, Multiple Drilling Heads and Machines, Tapping Machines, Gear Tooth Rounding Machines, Special Machine Tools for High Production.

Faces 3" diameter. Standard Vices have maximum bar capacity of $6\frac{1}{2}$ " diameter. Minimum length handled 6". Standard bed lengths to take work up to 24", 48" or 72" long.

HEY

ENGINEERING CO. LTD.
COVENTRY PHONE: COVENTRY 88641

Rathbone/1665

How does production grow?..



*...with Busy Bees
all in a row*

Some factories have rows of "Busy Bees" working for them—some have only one. But all agree they keep the wheels turning and production growing. And if you didn't know already, "Busy Bees" is the "nom de plume" of G.E.C. Fractional Horse Power Motors. As if they needed any disguise!

Phone your nearest G.E.C. dealer now and learn how G.E.C. Fractional H.P. Motors can help you.



**G.E.C.
Fractionals**

THE GENERAL ELECTRIC CO. LTD., MAGNET HOUSE, KINGSWAY, LONDON, W.C.2

**peak
power
service**



Books on every aspect of motor car maintenance and repair can be quickly obtained from Smith's. Lists of the appropriate technical books gladly supplied on request. Books not in stock quickly obtained to order. Our Postal Service sends books to any address at Home or Overseas.

W.H. Smith & Son

FOR TECHNICAL BOOKS

HEAD OFFICE: STRAND HOUSE, LONDON, W.C.2

PRESSWORK AND ASSEMBLY

BLANKING, DEEP DRAWING, WELDING



Blanking up to 24" x 18".

Drawing up to 8" depth

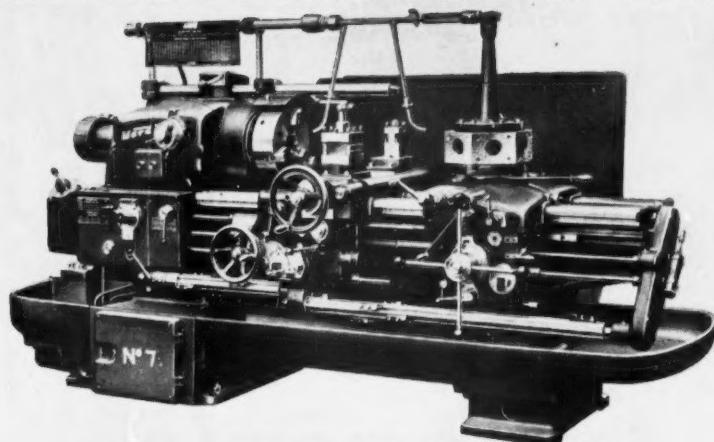
All types of presswork up to 200 tons capacity.

SAMUEL GROVES & Co. LTD.
MUSGRAVE ROAD, HOCKLEY, BIRMINGHAM, 18

Telephone :
NORTHERN 3634/5

Telegrams :
Sevorg, B'ham

For Maximum Production



Ward

No. 7 PRELECTOR
COMBINATION
TURRET LATHE

Capacity : 2½ in. dia. hole through spindle.
16 in. dia. swing over stainless steel bed covers.

Spindle: Mounted in ball and roller bearings.

Powerful metal-to-metal cone clutches transmit power through ground gears.

New features include patented hydraulic preselecting speed change system allowing for setting any operation speed whilst the previous operation is running. Maximum production is ensured by making full use of Tungsten Carbide cutting tools.

Please write for
particulars of our
full range of Caster
& Turret Lathes

H. W. WARD & CO. LTD

SELLY OAK
TELEPHONE



BIRMINGHAM 29
SELLY OAK 1131

W 608

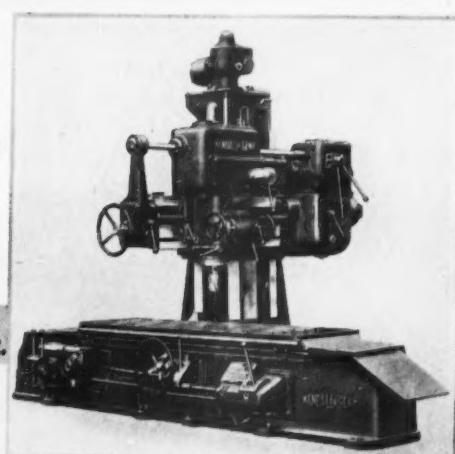
KENDALL & GENT OPENSIDE VERTICAL MILLING MACHINES

With vertical or horizontal heads

7ft. traverse

3ft. 7ins. under spindle

Table size 3ft. wide x 8ft. long



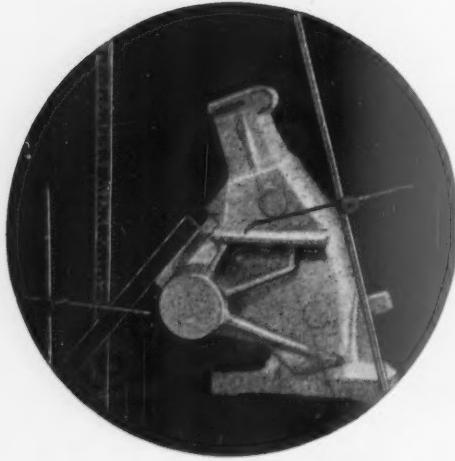
For many years Messrs. Rolls Royce have used different types of Kendall & Gent machines. Our illustrations show A.V.M.2 Openside Vertical Millers engaged on engine crankcases. Various operations are completed on these machines, one of which includes facing the top of the crankcase as shown in the close-up view.



KENDALL & GENT LTD.

GORTON, MANCHESTER 18
TELEPHONE: EAST 1035

K.224



Close Limit Accuracy cuts your machining costs

Three factors contribute towards making Shotton Bros. first in the field for BLACKHEART Malleable Iron Castings. Firstly, the attention paid to laboratory control at every stage in production, secondly, our 50 years experience in the Industry, and finally the up-to-date methods of production. The result is a casting of the highest possible quality,* accurate to fine limits, with subsequent machining costs cut to the minimum.

*Highest British Specification accepted—BSS 310 (1947) Grade 3. Fully machined components can be supplied.



OLDBURY, NEAR BIRMINGHAM
Telephone: BROadwell 1631-2.

TECONIC Members of the Technically Controlled Castings Group.

quality in STEEL



Dunelt

ALLOY AND SPECIAL CARBON STEELS

Black rolled, bright drawn or smooth ground, in heat treated or unheated conditions. Free cutting steels, heat resisting steels, die steels, shear blade steels, high speed tool steels, stainless steels, valve steels.

DUNFORD & ELLIOTT (Sheffield) LTD., Attercliffe Wharf Works, Sheffield, 9.
Telephone: 41121 (5 lines) Telegrams: "Blooms, Sheffield, 9".
Also at London and Birmingham.



P.V.C. WING PIPINGS, as supplied to leading motor manufacturers and body builders at home and abroad, have proved that plastic materials survive the severest tests. Whether as standard fittings used as wheel arch pipings or specially designed joint mouldings our sections are guaranteed to meet your particular requirements. Extrusions are our business—not just a department. Please write for brochure on extrusions for the motor industry.

C. & C. MARSHALL LTD.

PLASTRIP HOUSE
OAKLEIGH ROAD NORTH, LONDON, N.20
Telephone: Hillside 5041 (3 Lines) Cables: Tufflex, London
Telegrams: Tufflex, Norfinch, London

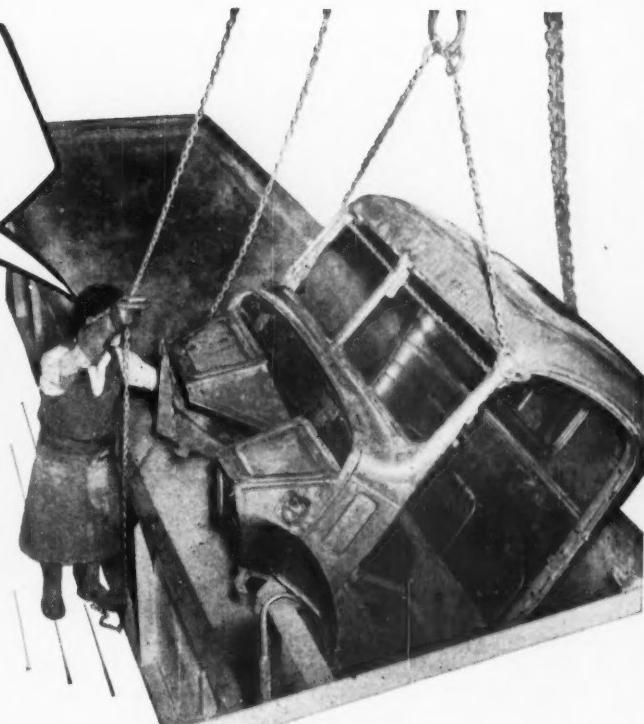


you're safely covered
when you **jenolize**
against RUST!

The simplest and most economical system of pre-treatment against rust is the jenolizing process, in which only three operations are necessary—(1) degreasing, (2) water rinse and (3) combined rust and scale removal, rust prevention and phosphate coating. The treated surface provides an excellent key for final painting and finishing, no neutralising being necessary.

Where vehicles are to be dispatched overseas in complete knock-down form, jenolizing gives full protection against rust.

Jenolite Ltd. supply and install complete treatment plants of any capacity. Their technicians will gladly advise on any problem relating to rust removal and prevention.



Jenolite
Ltd.

LONDON: 43, Piazza Chambers, Covent Garden, W.C.2. Tel: TEM. 1745, 3058, 5059

GLASGOW: Jenolite House, 304, High Street, Glasgow, C.4. Tel: Bell 2438/9

© 263/24

DAVID BROWN
AGRICULTURAL & INDUSTRIAL TRACTORS

USE
CLANCEY
CAST-IRON
VALVE GUIDES & CHILLED FACED TAPPETS

SUPPLIED AS CASTINGS OR FULLY MACHINED

G. CLANCEY LTD. · BELLE VALE · HALESOWEN
TELEPHONE CRADLEY HEATH 69411-2-3

Properties and temper in SPARK PLUG ALLOYS

GIVING THE BEST MANUFACTURING CONDITIONS

Spark plug alloys are no great problem in melting or rolling or drawing. But to provide a wire with just those physical properties and temper that a spark plug manufacturer requires demands something more than normal knowledge and normal care.

Round wire must have, besides a clean smooth surface, enough softness for the wire to function satisfactorily in a stamping machine, yet with the stiffness necessary for feeding into the machine. The right combination is very critical.

Flattened wire must have good weldability and ductility, with a stiffness that will ensure a proper spark gap being maintained over a long period.

We think we can help you with your own spark plug wire problems.

BRITISH DRIVER-HARRIS CO., LTD.
MANCHESTER 15



'THE ELECTRICAL ALLOY DATA BOOK'

*This is a most useful general reference.
Copies on request.*



NON-FERROUS CASTINGS

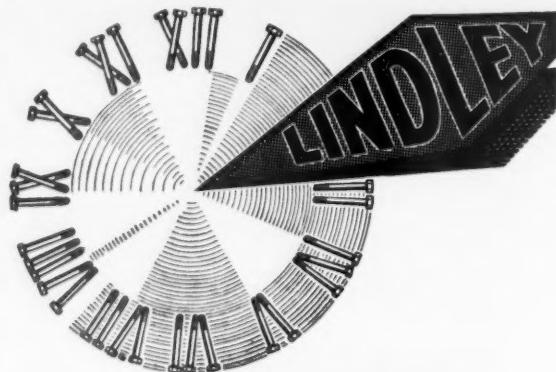
Made in a modern foundry planned for the production of non-ferrous sand castings, up to one ton in weight—in gunmetal, phosphor bronze, manganese bronze, aluminium bronze and aluminium alloy—with a reputation for purity, uniformity and durability.

A typical casting in high-strength Manganese Bronze.

WHYTE & COLLINS LTD
KELVIN WORKS, FENTON, STOKE-ON-TRENT

TELEPHONE
STOKE-ON-TRENT 48107
TELEGRAMS
ALLOYS STOKE-ON-TRENT

SM/YC.471b



**BOLTS, NUTS
& SET SCREWS
SERVE FOR
ALL TIME**

C. LINDLEY & CO., LTD.
ENGLEFIELD ROAD, LONDON, N.I.
Phone: Clissold 0643 (4 lines) Grams: BEAUVOIR, NORDO, LONDON



KEEPING COOL

at 172 m.p.h.! *

(on the Jabbeke Highway, Belgium)

**The record-breaking Jaguar was fitted with a
MARSTON RADIATOR –
as are all Jaguar cars**

* (Subject to official confirmation)

For assistance on any problem connected with heat exchange, write to

MARSTON EXCELSIOR LTD., WOLVERHAMPTON & LEEDS

(A subsidiary company of Imperial Chemical Industries Limited)





Four-stroke diesel engine cylinder liner showing the 9.6425" bore Monochrome processed with perfect oil control provided by the HONEYCHROME cellular surface.

**Resistance to wear
OF
DIESEL ENGINE
CYLINDERS IS**

*enormously
increased*

... if they are Honeychrome processed by

MONOCHROME
LIMITED



STUDLEY ROAD, REDDITCH, WORCS

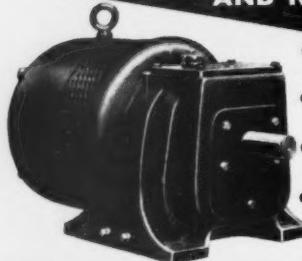
Telephone : Studley 121/2,3,4

22164A

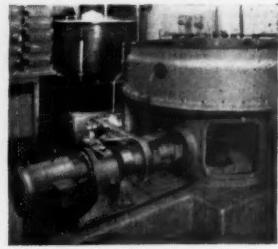
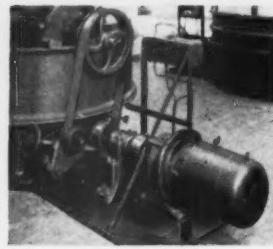
GLOVERS

134

Crofts "EFFICIENCY" GEARED MOTORS AND REDUCTION GEARS



- COMPLETELY SELF-CONTAINED POWER UNITS
- FOR ANY OUTPUT SPEED & FOR POWERS UP TO 80 H.P.
- FLOOR, WALL, OR CEILING MOUNTING
- ANY MAKE & TYPE of MOTOR
- MANY SIZES FROM STOCK



Applied in every trade and industry.

WRITE FOR PUB.D.M. 3/1.....OR RING Bradford 65251 EXT. 90

<i>Crofts</i>	CROFTS (ENGINEERS) LTD., BRADFORD	
	PHONE 65251 (15 LINES)	GRAMS CROFTS BRADFORD



**170 years old
reputation for quality...**

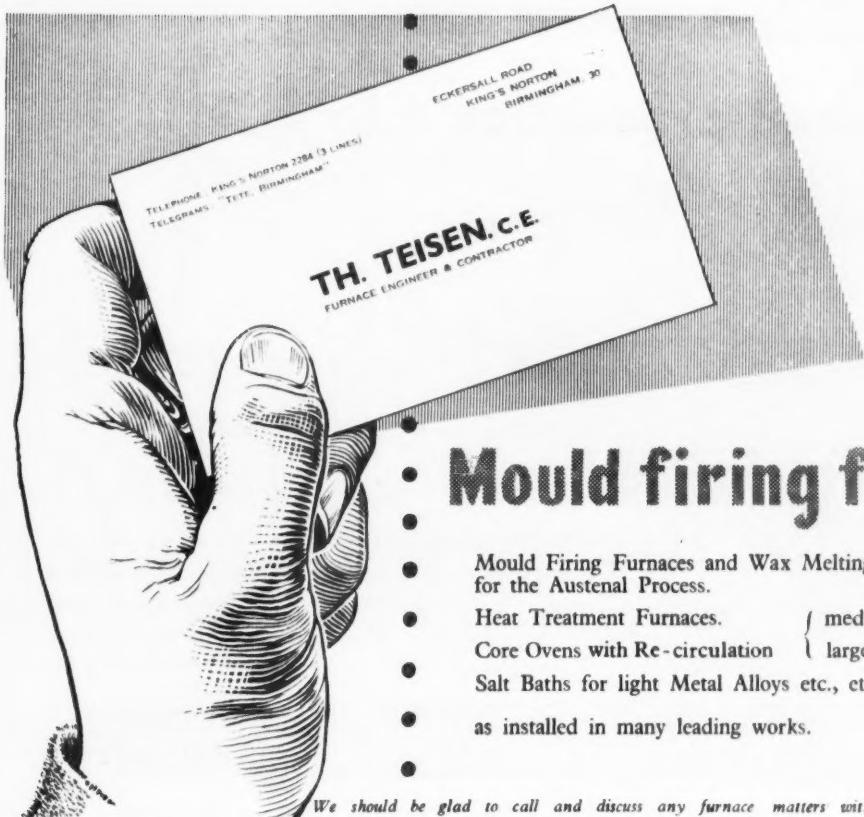
is unique, and can only be retained by the customer's verdict.

Another good reason why engineers prefer

KIRKSTALL BRIGHT
STEEL
BARS

CARBON AND ALLOY IN ALL STANDARD SECTIONS. ALSO SUPPLIED,
FULLY HEAT TREATED, TO ENGINEERING SPECIFICATIONS
KIRKSTALL FORGE ENGINEERING LTD - LEEDS 5 - Telephone : HORSFORTH 2821

M.13

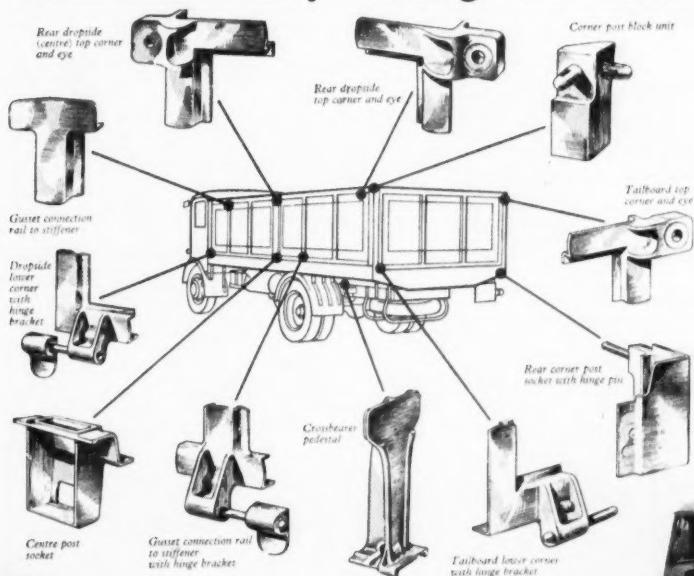


• Mould firing furnaces

- Mould Firing Furnaces and Wax Melting Ovens for the Austenal Process.
- Heat Treatment Furnaces. { medium to
- Core Ovens with Re-circulation { large sizes
- Salt Baths for light Metal Alloys etc., etc.
- as installed in many leading works.
-

We should be glad to call and discuss any furnace matters with you without any obligation.

Aluminium Alloy Castings for Commercial Vehicle Bodywork



In the construction of this all aluminium body, eighty light alloy castings of special design, produced by William Mills Ltd., are used in conjunction with sheet and sections supplied by the British Aluminium Company Limited



WILLIAM MILLS LIMITED

FRIAR PARK FOUNDRY, FRIAR PARK ROAD, WEDNESBURY, STAFFS.

© 180-79A

Increased production here



**Quality retained
everywhere!**

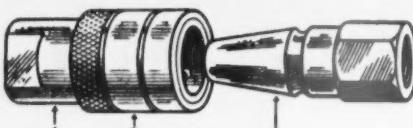
The PBM reputation for supplying quality castings and completely finished products is carefully maintained.

Another new factory extension enables us to offer to new customers immediate supplies—identical to those upon which the PBM reputation has been built. We invite you to call and inspect these latest PBM Castings, Machining and Assembling facilities.

PERRY BARR METAL COMPANY LTD



OSCOTT WORKS · GREAT BARR · BIRMINGHAM · 22A



QUICK DETACHABLE PIPE COUPLING

for use on trailers with tractor controlled brakes. Body 'A' fixed on back of tractor, operation is as follows: Move sleeve 'B' back, this allows steel retaining balls to open and release cone 'C'. When connecting, hold sleeve 'B' back while inserting cone. Internal spring then returns sleeve to "locked" position. Rotate sleeve for safety lock. Couplings rustproofed. Can be used for vacuum or pressure. Standardised by S.M.M.T.; in general use in America. Safe working load of 4,000 lbs. per sq. inch. Can be supplied with an automatic shut-off valve. Now available in $\frac{1}{2}$, $\frac{3}{4}$, $1\frac{1}{2}$ bore.

FEENY & JOHNSON LTD WEMBLEY

Phone: WEMbley 4801/2

MODERN SINGLE-STOREY
FACTORY
OF APPROX. 70,000 SQUARE FEET
REQUIRED

IN A LONDON SUBURBAN AREA
SUITABLE FOR PRINTING WORKS

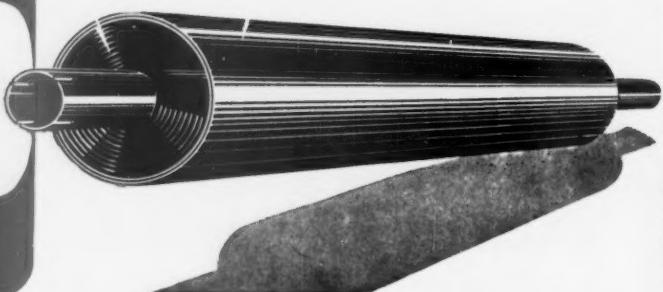
Particulars of premises with early
vacant possession are requested by:

CHAMBERLAIN & WILLOWS
23 MOORGATE, LONDON, E.C. 2
CITY 6013 (6 lines)

MORE SILENT AND EFFICIENT

Silencers of all types, for Cars, Commercial Vehicles, Tractors and Marine purposes.

Any type of Silencer made to your own specifications. Straight thro' — Two — Three and Six pass, also Standard Baffle Type. Enquiries cordially invited.



Tel: Colneeth 2167/8 - Col 3133. (Grams: Perfecto - Glassbury)



Spencer Tools

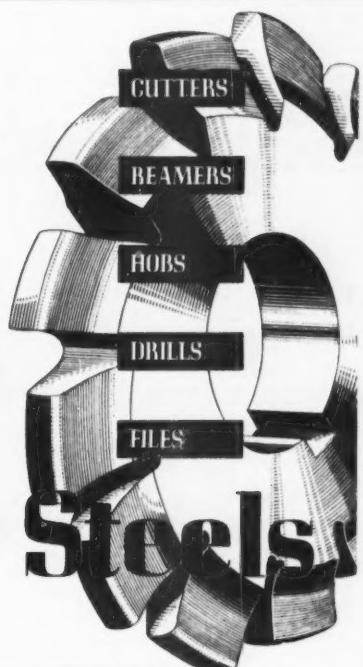
made from **Spencer Stocks**

STANDARD & SUPER GRADES.
SPENCER SPECIAL STEEL.

"VELOS" High Speed Steel and Tools.

"TRIPLE CRESCENT" Alloy Tool Steels, Broaches, Stay Taps, Machine Parts, etc.

"CRESCENT" Tool Steel and Tools.



WALTER SPENCER & CO. LTD.,
CRESCENT STEEL WORKS, SHEFFIELD, 4.

Telephone: SHEFFIELD 25281 (2 lines).

Telegrams: "CRESCENT SHEFFIELD, 4."

AND AT LONDON · BIRMINGHAM · MANCHESTER



QUALITY CONTROL

at all stages of manufacture ensures a trouble free product . . . the reason why most manufacturers use High Tensile Cylinder Head, Gear Box and other Studs made

by

YARWOOD INGRAM & CO LTD
PARKER ST. BIRMINGHAM. 16.
TELEPHONE: EOCbaston.3807.

CLASSIFIED ADVERTISEMENTS

RATE 4d. per word, minimum 4/- Each paragraph charged separately. Box number 5 words—plus 1/- Advertisements for the January, 1954, issue should be to hand not later than first post December 28th. No responsibility accepted for errors.

CAPACITY AVAILABLE

I.F.A. Engineering Limited have available at their Hanworth depot all the equipment necessary for testing engines rated from zero to 80 h.p.

THEY are anxious to make contact with individuals or organizations requiring this service who are requested to apply for fuller particulars to I.F.A. Engineering Limited, 13-15, Rathbone Street, London, W.I. (Tel. Museum 5411). [4756]

DYNAMIC Balancing. Crankshafts, rotors, fans, etc. Capacities available 20 to 600 lb., max. length 5 ft. Collection and delivery by arrangement. South-East Midlands. Box 2102, c/o Automobile Engineer. [4760]

PATENTS

THE proprietor of British Patent No. 627023, entitled "Improvements in or Relating to Vehicle Undercarriages" offers same for licence or otherwise to ensure practical working in Great Britain. Enquiries to Singer, Stern & Carberg, 14 E. Jackson Boulevard, Chicago 4, Illinois, U.S.A. [4755]

SITUATIONS VACANT

The engagement of persons answering these advertisements must be made through the local office of the Ministry of Labour and National Service, etc., if the applicant is a man aged 18-65 or a woman aged 18-59 inclusive, unless he or she or the employer is excepted from the provisions of The Notification of Vacancies Order, 1952

DRAUGHTSMAN—Senior, with automobile experience for work on new project. Harry Ferguson Research Ltd., Fletchamstead Highway, Coventry. [4757]

JOSEPH LUCAS Ltd. require a young Automobile Engineer for the coldroom section of their Proving Laboratory. Duties include investigations into the starting of I.C. engines under low temperature conditions and other allied problems. Applicants should have H.N.C. in mechanical engineering and experience in the testing of automobile engines is desirable. Please reply stating qualifications, experience and age to Personnel Manager, Joseph Lucas Ltd., Great King Street, Birmingham, quoting reference PM/D/88. [4758]

DESIGN and Production Draughtsmen for work in an expanding division, dealing with new types of commercial vehicle and space heating. Previous experience in this field is not essential, but applicants should preferably possess H.N.C. or equivalent. Vacancies are at Cricklewood. Staff Pension, Bonus. Salary in keeping with experience and qualifications. Apply in writing, with full particulars, to Personnel Manager, S. Smith & Sons (England) Ltd., Cricklewood Works, London, N.W.2, quoting reference: MAI/PLI/8. [4754]

NITRIDED

NITRALLOY STEEL

for

OPTIMUM HARDNESS & STRENGTH

Particulars from

NITRALLOY LIMITED

25, TAPTONVILLE ROAD
SHEFFIELD 10

Telephone: Sheffield 60689 Telegrams: Nitralloy, Sheffield.

BOLTS with NUTS

for the

AUTOMOBILE INDUSTRY



Made to customer's specification
in any quantity.
For precision parts from the bar
in any metal, particularly those
which are not produced by the
cold head or roll threaded process
... consult the specialist
machinists.

M.C.L. & REPETITION LTD.

POOL LANE • LANGLEY • BIRMINGHAM
Telephone: Broadwell 1115 (4 lines) and 1757.



COTTON BAGS FOR SPARE PARTS Etc.

Walter H. Feltham & Son Ltd
Imperial Works, Tower Bridge Road
Telephone: HOP 1784. LONDON, S.E.1

SITUATIONS VACANT

RESEARCH and Development Worker required in the development department of large Midland motor firm. Higher National Certificate or equivalent. Write stating training experience and qualifications. Box 1667 c/o Automobile Engineer. [4751]

SALESMAN with practical and expert knowledge modern Machine Tools wanted. Only first-class men with experience and good connections with Midland Motor Industry need apply. Interesting position and good income for right man. Box M/922, Strand House, London, W.C.2. [4761]

DESIGNER. An enthusiastic and experienced Designer is required to take charge of the drawing office in the research department of a large engineering firm in the Midlands. There are excellent opportunities for the right man, who should have experience in the design of small high performance I.C. engines. Box 1290, c/o Automobile Engineer. [4742]

AUTOMOBILE Body Draughtsman (layout and detail). An immediate vacancy exists for a man with the right background and experience on interesting and progressive work on development and design of all steel automobile bodies. Man with sound engineering draughtsmanship background would be considered for either junior or senior positions. Write giving details of age, experience, etc., to Personnel Manager, Carbodies Limited, Holyhead Road, Coventry. [4750]

THE Society of Motor Manufacturers and Traders Ltd., invites applications for post of Technical Officer. Age 35-45 preferred. Qualifications should include engineering degree or corporate membership I.Mech.E. and experience as executive in vehicle design and/or manufacture and use. French desirable. Commencing salary in accordance with qualifications, experience and age. Pension scheme. Applications to the Director, 148, Piccadilly, London, W.I. by December 15th, marked "Confidential." [4759]

BOOKS

HARDFACING by Welding. By M. Ridgough, M.Met., A.R.I.C., F.I.M. A practical manual covering every stage of the process—design of components, choice of hardfacing alloy and technique of depositing, inspection and finishing methods. 8s. 6d. net from all booksellers. 8s. 10d. by post from The Publishing Dept., Dorset House, Stamford Street, London, S.E.1.



MEK-ELEK Engineering Ltd
17 Western Road, Mitcham, Surrey.

25 Years Experience
1928-1953

As manufacturers of small components to the Automobile Industry, we have experience behind us now extending over 25 years. We specialise in mouldings to your own drawings and specifications for which our tool-room is fully equipped.

Telephone: COLmore 4270
Telegrams: "ARISUN, Phone, Birmingham".



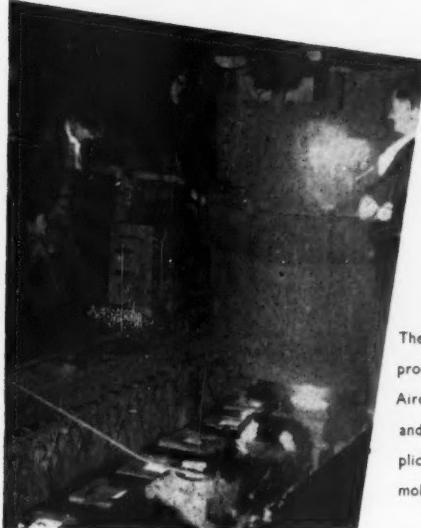
HARRISON BROS
PLASTICS LIMITED

59-43, BRANSTON ST, BIRMINGHAM 18

F.J. Edwards Ltd

SHEET METAL MACHINERY • MACHINE TOOLS • WOODWORKING MACHINERY

ALL TYPES—NEW & USED. ASK FOR LISTS.



THE DARWINS GROUP

SHEFFIELD · ENGLAND

The comprehensive range of the Darwins Group products is designed to meet the needs of the Aircraft, Automobile and Engineering Industries and to provide steels for many special applications. Illustration shows teeming a ladle of molten steel into ingot moulds.



DARWINS LTD.

TOOL STEELS · HACKSAW BLADES · PERMANENT MAGNETS · HEAT & ACID RESISTING CASTINGS

ANDREWS TOLEDO LTD.

CARBON & ALLOY CONSTRUCTIONAL STEELS

WARDSEND STEEL CO. LTD.

AGRICULTURAL & TOOL STEEL SHEETS

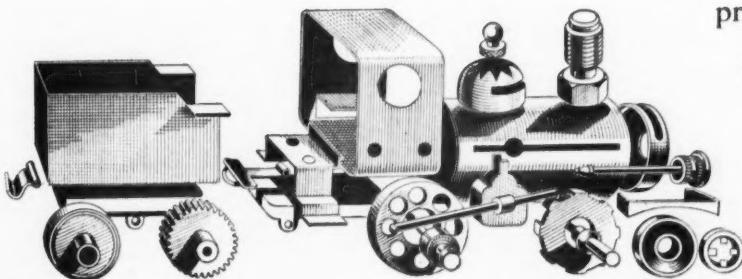
ANDREWS TOLEDO (WIRE ROD) LTD.

SPECIAL CARBON & ALLOY WIRE ROD

Craftsmen in Steel

D.55

HIGH SPEED AUTOMATICS



Modern machinery and mass production methods give you top quality capstan and automatic work and sheet pressings at a price you are sure to like—and on time.

GRIFFITHS, GILBART, LLOYD & CO. LTD.
EMPIRE WORKS · PARK ROAD · BIRMINGHAM 18
Telephone : NORthern 6221.



SULFLOID

Straight Cutting Oils

The High Duty,
General Purpose Oil
used from Automatics
to Broaches.

PHONE: LONDON—WHITEHALL
0484 OR BIRMINGHAM—PRIORY
2570 FOR OUR TECHNICAL
SERVICE

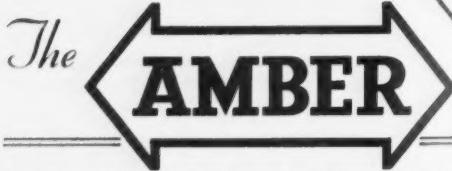


Photo by Courtesy of
Kirkstall Forge Ltd.
of their "Bar
Automatics."

at KIRKSTALL FORCE

The use of SULFLOID ensures :—

- ★ Extreme Film Strength ★ Maximum Tool Life
- ★ Improved Tool Bite ★ Superior Surface Finish
- ★ No Swarf—Welding ★ Minimum Cycle Time ★ Fewer Operations



C H E M I C A L C O . L T D .

11A ALBEMARLE STREET, LONDON. MAYFAIR 6161/2/3

Works: LONDON (Phone: EAST 1788) WOLVERHAMPTON (Phone: 22591) CLECKHEATON, YORKS. (Phone: 1104/5)

INDEX TO MANUFACTURERS' ANNOUNCEMENTS

PAGE	PAGE	PAGE	PAGE	PAGE	
Accles & Pollock, Ltd.	90	Cole, E. K., Ltd.	114	Humphreys, J. H. & Sons	124
AC-Delco Division of General Motors, Ltd.	34	Cooper & Co. (Birmingham), Ltd.	98	I.C.I. (Maraton Excelsior, Ltd.)	133
Acheson Colloids, Ltd.	40	Coopers Mechanical Joints, Ltd.	43	Iford, Ltd.	79
Adamant Engineering Co., Ltd.	103	Cork Manufacturing Co., Ltd.	63	Intalok, Ltd.	112
Adams Bros., & Burnley, Ltd.	96	Council of Ironfoundry Associations, The	Cover iii	International Twist Drill Co., Ltd., The	110
Aerialite, Ltd.	118	Coventry Motor Fittings Co., Ltd.	27	Iso-Speedic Co., Ltd., The	28
Aerograph Co., Ltd., The	92	Crofts (Engineers), Ltd.	134	Jackson, H., Ltd.	71
Aluminium Bronze Co., Ltd.	125	C.T.D. (Birmingham), Ltd.	120	Jenks, A. E. & Cattell, Ltd.	108
Alumal, Ltd.	116	Darwins, Ltd.	139	Jenolite, Ltd.	131
Amber Chemical Co., Ltd., The	140	Dawne Instruments, Ltd.	96	Jessop, William, & Sons, Ltd.	115
Anderton Springs, Ltd.	146	Desoutter Bros., Ltd.	21	Johansson, C. E., Ltd.	42
Andre Rubber Co., Ltd.	78	Dobbie, McInnes, Ltd.	124	Johnson, & Johnson (Great Britain), Ltd.	110
Archdale, James & Co., Ltd.	24	Doncaster, Daniel & Sons, Ltd.	93	Kayser Ellison & Co., Ltd.	77
Automotive Products Co., Ltd.	125	Dover, Limited	86	Kendall & Gent, Ltd.	129
B.B. Chemical Co., Ltd.	5, 6, 7, 8	Dowty Seals, Ltd.	16	Kirkstall Forge Eng., Ltd.	99
Beck Koller & Co. (England), Ltd.	104	Dunford & Elliott (Sheffield), Ltd.	130	Lathom Engineering Co., Ltd.	136
Benton & Stone, Ltd.	106	Dunlop Rubber Co., Ltd.	87	Lee, Arthur, & Sons, Ltd.	54
Birlec, Ltd.	28	Firth Brown Tools, Ltd.	17	Ley, Spring Co., Ltd., The	116
Birmetals, Ltd.	101	Firth-Derlithon (Stampings), Ltd., The	29	Ley's Malleable Castings, Ltd.	45
Birmingham Aluminium Casting (1903) Co., Ltd.	Cover iv	Fletcher, Miller, Ltd.	125	Lindley, C. & Co., Ltd.	132
Birmingham Tool & Gauge Co., Ltd.	106	Folman Wycliffe Foundries, Ltd.	51	Linread, Ltd.	117
Black & Decker, Ltd.	80	Fetham, Walter H., & Sons, Ltd.	138	Lloyds (Burton), Ltd.	119
Booth, J. & Co., Ltd.	109	Ferodo, Ltd.	64, 65	Marbach, Gaston E., Ltd.	22, 23
Bound Brook Bearings (G.B.), Ltd.	67	Firth Brown Tools, Ltd.	17	Marshall, C. & Co., Ltd.	130
Briscoe, W. H. & Co., Ltd.	118	Funditor, Ltd.	100	Mavitra Drafting Machines, Ltd.	126
British Driver-Harris Co., Ltd.	132	Garringtons, Ltd.	94	M.C.L. and Repetition, Ltd.	138
British Electrical Development Association	2	Gas Council, The	49	Meddings, W. J., Ltd.	120
British Oxygen Co., Ltd., The	90	General Electric Co., Ltd., The	44, 128	Mek-Elekt Engineering, Ltd.	138
British Timken, Ltd.	Cover	Girling, Ltd.	57	Metalastik, Ltd.	13
Brown, David, & Sons (Huddersfield), Ltd.	75	Glacier Metal Co., Ltd., The	105	Metropolitan-Vickers Electrical Co., Ltd.	88
Burton Griffiths & Co., Ltd.	70	Griffiths, Gilbert, Lloyd & Co., Ltd.	139	Midland Mechanical Developments, Ltd.	95
Bury Felt Mfg. Co.	4	Groves, Samuel & Co., Ltd.	128	Midland Motor Cylinder Co., Ltd., The	25
Bushing Co., Ltd., The	68	Habershon, J. J. & Sons, Ltd.	111	Mills, William, Ltd.	135
Cape Asbestos Co., Ltd., The	46, 47	Hardy Spices & Co., Ltd.	123	Mond Nickel Co., Ltd., The	56
Carobronze, Ltd.	126	Harper, J. & Co., Ltd.	11	Monks & Crane, Ltd.	3
Carr Fastener Co., Ltd.	108	Harrison Bros. (Plastics), Ltd.	138	Monochrome, Ltd.	134
Cary, Wm. E., Ltd.	122	Herbert, Alfred, Ltd.	73	Moss Gear Co., Ltd.	88
Cassell Cyanide	82	Hey Engineering Co., Ltd.	127	Neill, James & Co. (Sheffield), Ltd.	91
C.A.V., Ltd.	62	Hoffmann Manufacturing Co., Ltd., The	85	Newall, A. P. & Co., Ltd.	112
Chamberlain & Willows	136	Holroyd, John & Co., Ltd.	53	Newton & Bennett, Ltd.	107
Churchill, Charles & Co., Ltd.	116			Nitralloy, Ltd.	138
Clancey, G., Ltd.	131			Northern Aluminum Co., Ltd.	20
Clayton Cranes & Hoist Co., Ltd., The	92			Osborn, Samuel & Co., Ltd.	104
Clayton Dewandre Co., Ltd.	19			Perry Barr Metal Co., Ltd.	136
Cleveland Petroleum Co., Ltd.	113			Perry Chain Co., Ltd.	118
Clifford, Chas., Ltd.	124			Poplock & Peel, Ltd.	86
Climax Molybdenum Co. of Europe, Ltd.	58			Pressed Steel Co., Ltd.	30, 31
				Yarwood, Ingram & Co., Ltd.	137

Printed in Great Britain for the Publishers, ILIFFE & SONS LTD., Dorset House, Stamford Street, London, S.E.1, by James Cond Ltd., Charlotte Street, Birmingham 3. "Automobile Engineers" can be obtained abroad from the following: AUSTRALIA & NEW ZEALAND: Gordon & Gotch Ltd. INDIA: A. H. Wheeler & Co. CANADA: The Wm. Dawson Subscription Service Ltd. GORDON & GOTCH LTD. SOUTH AFRICA: Central News Agency Ltd. Wm. Dawson & Sons (S.A.) Ltd. UNITED STATES: The International News Co. Entered as Second Class Matter at the New York, U.S.A., Post Offices.

GREY and MALLEABLE

IRON CASTINGS

*Create
Confidence*

- * ASSIST DESIGN
- * REDUCE COSTS
- * AID SALES



ISSUED BY THE COUNCIL OF IRONFOUNDRY ASSOCIATIONS
CRUSADER HOUSE, 14 PALL MALL, LONDON, S.W.1

GASTING OPERATION

SAVES

ASSEMBLY

COSTS

Pressure die castings in aluminium alloy form the major body components of the "Flamemaster" hand torch illustrated here by courtesy of Messrs. Chance Bros. Ltd. Our customer says: "The aluminium die castings which we have obtained from you for use on this product have proved entirely satisfactory, and are a great improvement on the previous covers. It is in fact true to say that they save us considerable assembly cost due to their accuracy of fit and excellent finish." Extract of letter from Messrs. Chance Brothers Ltd., Smethwick, Birmingham 40.

BIRMAL

BIRMINGHAM ALUMINIUM CASTING (1903) CO LTD
BIRMINHAM WORKS · SMETHWICK · BIRMINGHAM 40
LONDON OFFICE 20-22 BERKELEY SQUARE, LONDON, W1